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ABSTRACT

Seven papers from the 1987 CAUSE conference's Track VI, Hardware/Software Strategies, are presented. They include: "Integrated Systems--The Next Steps" (Morris A. Hicks); "Administrative Microcomputing--Roads Traveled, Lessons Learned" (David L. Smallen); "Murphy's First Law and Its Application to Administrative Computing" (Mary Lawarre Cox and William E. Updegraff); "Leveraging Relational Technology through Industry Partnerships" (Leonard M. Brush and Anthony J. Schaller); "Strategies to Implement Technology to Manage and Deliver Educational Programs in a Decentralized Organization" (Thomas R. McAnge, Jr.); "Fourth Generation Languages in a Production Environment" (Sharon P. Hamilton); and "Automated Design Tools: Paradise or Promises?" (David Battleson, Marshall Drummond, John Moylan, and Ruth Strausser). (LB)

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Leveraging Information Technology

Proceedings of the 1987 CAUSE National Conference

TRACK VI: Hardware/Software Strategies

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CAUSE, the Professional Association for Computing and Information Technology in Higher Education, helps colleges and universities strengthen and improve their computing, communications, and information services, both academic and administrative. The association also helps individual members develop as professionals in the field of higher education computing and information technology.

Formerly known as the College and University Systems Exchange, CAUSE was organized as a volunteer association in 1962 and incorporated in 1971 with twenty-five charter member institutions. In the same year the CAUSE National Office opened in Boulder, Colorado, with a professional staff to serve the membership. Today the association serves almost 2,000 individuals from 730 campuses representing nearly 500 colleges and universities, and 31 sustaining member companies.

CAUSE provides member institutions with many services to increase the effectiveness of their computing environments, including: the Administrative Systems Query (ASQ) Service, which provides to members information about typical computing practices among peer institutions from a data base of member institution profiles; the CAUSE Exchange Library, a clearinghouse for documents and systems descriptions made available by members through CAUSE; association publications, including a bi-monthly newsletter, *CAUSE Information*, the professional magazine, *CAUSE/EFFECT*, and monographs and professional papers; workshops and seminars; and the CAUSE National Conference.

We encourage you to use CAUSE to support your own efforts to strengthen your institution's management and educational capabilities through the effective use of computing and information technology.

INTRODUCTION

As professionals in an always-exciting field, we are constantly facing challenges to blend new information technologies into our institutions. It is important for higher education to develop environments that promote the use of information technology for strategic advantages, that allow faculty, staff, and students to benefit from existing technology, and that stimulate the discovery of new opportunities.

The 1987 CAUSE National Conference, with its theme "Leveraging Information Technology," offered the opportunity for us to share, exchange, and learn of new developments in information technology to improve and enhance our environments. The CAUSE87 program was designed to allow the fullest possible discussion of issues related to these new developments. Seven concurrent tracks with 49 selected presentations covered important issues in general areas of policy and planning, management, organization, and support services, as well as in the specialized areas of communications, hardware/software strategies, and outstanding applications.

To expand opportunities for informal interaction, some changes were made in the program schedule. CAUSE Constituent Groups met the day before the conference, as they did in 1986, but were given opportunities to meet again during the conference. Current Issues Sessions were moved to Thursday afternoon to provide some flexibility with time, encourage interactive participation, and extend opportunities to continue discussions with colleagues. Vendor workshops were offered for the first time this year, the day before the conference. The Wednesday afternoon schedule accommodated continued vendor workshops, vendor suite exhibits, and concurrent vendor sessions.

David P. Roselle, President of the University of Kentucky, set the tone for CAUSE87 with a Wednesday morning opening presentation expressing his commitment to the value of information technology in higher education. John G. Kemeny, past president of Dartmouth College and currently Chairman of the Board of True BASIC, Inc., spoke during Thursday's luncheon of new developments in computing for classroom learning. The concluding general session, Friday's Current Issues Forum, offered an exchange of philosophies about making optimal use of technologies on our campuses.

We were extremely fortunate to be at Innisbrook, a resort with outstanding conference facilities and great natural beauty (and weather)—a real distillation of the best of Florida.

Almost 800 people attended CAUSE87. Many of them described the conference, in their evaluation forms, as stimulating, informative, and memorable. We hope this publication of the substance of CAUSE87 will be a continuing resource, both for conference-goers and for those who will be reading about the conference offerings for the first time.

Wayne Donald
CAUSE87 Chair

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Track VI

Hardware/Software Strategies

Coordinator:
Frank Weiss
Barnard College

Planning and successfully implementing information technologies in academic and administrative environments require both short- and long-range strategies for hardware and software, spanning personal computers and supercomputers, spreadsheet packages, and fourth-generation languages. Papers in this track examine such planning strategies, implementations, and successful programs.

Mary Lawarre Cox
Wittenberg University

Leonard M. Brush
Carnegie Mellon University

Morris A. Hicks
University of Hartford

"INTEGRATED SYSTEMS - THE NEXT STEPS"

Morris A. Hicks

Associate Director
Computer Services Department

University of Hartford

West Hartford, CT

ABSTRACT

The University of Hartford had the necessary infrastructure in place to capitalize on its investment in four major integrated systems, when the current data base vendor and application software vendor joined to offer a package of software products. Project goals were to upgrade to an advanced relational data base management system, to provide on-line management summary inquiry facilities and a new query facility for direct on-line access by end users, and to install a fourth generation language. Since this would be the first installation of these products in an operational environment, flexibility of plans and execution would be required.

The value of having a solid foundation of stabilized systems, experienced staffs, commitment of management, flexible planning, and staff training is emphasized. Experience of migrating existing systems, conversion of the data bases, and impact upon computer operations will be discussed.

"INTEGRATED SYSTEMS - THE NEXT STEPS"

Introduction

In the early 1980's, the University of Hartford initiated a review of administrative systems and undertook the strategic project to install a series of advanced, integrated information systems. During an 18 month period, four administrative systems were installed. These systems were the accounts receivable (ARIS), human resources and payroll (HRIS), financial information (IFIS), and student information (ISIS) from the selected vendor, Systems and Computer Technology or SCT. About a year and a half later, these systems had been stabilized and the necessary infrastructure was in place and so that the University could consider a opportunity to capitalize on its investment.

The opportunity focused on three areas: accessibility of data by management, replacement data base management system, and tools for easing the application system back log. The application systems had become integral to the operating departments but had not sufficiently satisfied the management information needs. The data base technology to allow secure access to the information was one need for an advanced data base management system. Another was that the current data base management system, TOTAL, was in a "maintenance status" and had to be replaced in any case.

The project goals were to install an advanced relational data base management system (SUPRA), an on-line management query system (part of Symmetry), a new query facility (SPECTRA) for direct on-line access by management personnel and a fourth generation language (MANTIS) for analysts and programmers.

It was recognized that this would be the first project of this type in a production environment and therefore flexibility of plans and execution would be required. The solid foundation of operating experience and expertise of systems professionals and of management and supervisory end users was essential. The importance of experienced administrative and operating management in user departments must be emphasized. Not only were they very knowledgable in understanding their systems but also in system implementation projects. This first hand experience was a key resource in pursuing a very progressive project plan. They had successfully completed larger, more difficult projects before and so knew what to do and what trials and frustrations to expect.

This paper focuses on the process of planning and execution rather than on technical details and broader institutional issues.

Background on the University of Hartford

The University of Hartford is an independent, comprehensive university which provides educational programs in the liberal arts and professional disciplines for undergraduate and graduate students. There are 155 graduate and undergraduate majors and degree programs. Most of the 4,200 full-time undergraduate students come from the northeast part of the United States. In addition there are 7,000 others enrolled in part-time undergraduate and graduate programs and noncredit courses.

The University campus is situated on a 230+ acre suburban setting in the greater Hartford area and has practically all of its facilities (colleges, dormitories, and administration buildings) on this contiguous piece of land.

Computer and Human Resources

In recognition of the University's investment in its integrated information systems, the computer resource had been upgraded to an IBM 4381 (MVS operating system) with 130 terminals for the administrative users and the systems staff had been expanded and highly trained. Particularly important was the staffing in the application systems area, where a relatively small staff had attained a high level of expertise. This expertise was evidenced by the growing number of vendor supplied enhancements placed into production.

Equally important was a knowledgable and experienced community of end users. A large number had participated in the original installation of the information systems and now used them in an operational environment.

General Objectives and Goals

With this foundation, the portfolio of information systems could then be viewed from a longer term and more flexible perspective as to what would be the next steps to build upon the institution's investment. The general goals were to enhance and improve the installed application systems and to build upon these systems and provide new strategic components (including direct access to the on-line data). The investment in the information systems could be leveraged by increasing the scope and increased strategic use of the information resources.

The paths to accomplish these objectives were many. For example, vendor and in-house enhancements could be installed one by one to each of the systems or the current baseline software could be installed. A replacement data base management system was also a part of future plans.

Status of Application Systems

The four major information systems were advanced, integrated, on-line and batch applications from Systems and Computer Technology (SCT), that had been adapted to the University's environment. These adaptations varied from system to system. All of the systems had become an integral part in department operations.

Major Administrative Application Systems

Account Receivable Information System (ARIS)

Human Resources Information System (HRIS)
(human resource department functions, payroll)

Integrated Financial Information System (IFIS)
(fund accounting, budgeting, accounts payable)

Integrated Student Information System (ISIS)
(admissions, registration, financial aid, course catalogue, fee assessment, housing, academic history)

In reviewing the portfolio, a number of aspects were investigated. Some of the more important areas were:

Application Systems Portfolio Review

Adaptation - Degree of adaptation versus vendor's current baseline

Stability - Comparative stability of the information system

Data Structure - Data structure for each information system ("TOTAL" DBMS or VSAM files)

Functionality - End user conclusion on the functionality of the current system as compared to the current baseline product

Enhancements - Implementation of the vendor supplied enhancements

Alternative - Feasibility and project estimates

While the level of expertise of the applications staff allowed a significant number of vendor supplied enhancements to be installed, the number of enhancements varied from system to system. In particular the human resources system (payroll portion) did not have the smooth operation that permitted enhancements to be installed. Too many resources were diverted to handle the day to day operation of this (HRIS) system. With the excellent institutional foundation in both trained personnel and information systems, consideration could be given to upgrade certain systems to the most recent releases and thus bypass the enhancement by enhancement process.

Another candidate was the Accounts Receivable system (ARIS); however the extent of adaptations gave pause to the consideration of upgrading that system for the time being. The financial system (IFIS) was the most stabile of the systems. However IFIS was not the TOTAL version as were all of the others but the VSAM version. The largest system of the four systems by far was (and is) the student information system (ISIS), which was stabile and had a number of major enhancements installed. For ISIS, the Tuition Assessment portion had been greatly expanded by the University to provide a very flexible tuition and fee assessment module.

Major Long Range Plan Components

It is well to note the difference between an upgrade to a baseline and an installation of a software product for the first time. First time installations are massive projects when compared to the upgrade of existing software within a product line. In this context upgrades are updates and extensions, which are unlike first time installations.

Of the systems, the human resources/payroll (HRIS) system was the most logical candidate for an upgrade and this project was begun in 1986 and finished in early 1987. The next most logical candidate for upgrading was the financial system (IFIS), but equally important was a replacement data base management system (DBMS).

Component	Possible Plan - Current Status
Accounts Receivable (ARIS)	Upgrade to baseline - Deferred
Human Resource/Payroll (HRIS)	Upgrade to baseline - Completed
Financial System (IFIS)	Upgrade to baseline - In progress
Student System (ISIS)	Major enhancements continuing
Data Base Management System	Replacement DBMS - Completed
Query Facility and 4GL	Installation - Completed

Data Base Management System - TOTAL to ?

The data base management system being used to support the installed SCT systems was TOTAL from CINCOM Systems. This was a stable, "work horse" product; however it was an older technology that was destined to be superceded. Long term planning recognized that a new data base management system (DBMS) would have to be installed. It was also recognized that the currently installed TOTAL DBMS product had been highly tuned over the last few years. Furthermore, it was much simpler in operation and in performance tuning than any of the newer relational data base management systems being considered as replacement candidates.

There were a number of major areas of comparison for a prospective data base management systems (DBMS). The data files, the job control statements (JCL), and the programs required a careful review of their migration options and risks associated with each candidate DBMS. This was especially true since neither the existing staff would be increased nor were there to be large expenditures available for contract programming support.

Training of the Computer Services staff would need to be done before the installation of any new product. Timing of any move to production would need to be considered very carefully as to allow for the majority of the work to be done outside of the heavy usage periods in the academic calendar and to allow for substantial tuning of any new DBMS before the next such heavy usage period occurred.

DBMS Selection Criteria

Experienced Product - To be a proven product with a significant number of sites in production with COBOL programs.

Migration - To migrate with ease and security to the new environment as well as the flexibility to return to the old.

Program Changes - Not require logic changes to the existing application programs.

Functional Transparency - No end user training required.

Performance - To be at least as good as with the current DBMS.

Advanced Relational Technology - To provide immediate benefits while providing a basis for the future.

Ad Hoc Query - To allow direct access by end user staff, while maintaining confidentiality and integrity of the data base files.

4GL - A fourth generation language (4GL).

Thus, as the list indicates, there were a large number of important "nuts and bolts" to be concerned about in actually implementing a change in the DBMS - not to mention the very important long term institutional objectives for the application systems and increased utilization of the information resource.

The SUPRA/Symmetry Package

Fortuitously, the current application software vendor (SCT) and the current DBMS software vendor (CINCOM Systems) forged a joint program to offer a package of an advanced relational DBMS and an Administrative Inquiry system designed to fit within and build upon the University's existing application software base and data files. University management reviewed this opportunity and was positive in its conclusion.

SUPRA, the new advanced data base management system from CINCOM, had already been identified as one of the prime candidates for the next DBMS and had scored high in the selection criteria. SUPRA is one of the leading advance technology DBMS's and comes with a fourth generation language (MANTIS) and an ad hoc query system (SPECTRA). SUPRA passes data defined by external schemas or data "views"; these data "views" can be defined for each end user and have security to the record and element/field level. Since TOTAL is also CINCOM's product there is a high level of support for migration tools and conversion guidelines. Another plus for SUPRA was that it was already installed in the local Hartford area at a number of commercial sites. In fact one of the companies had been a "beta" test site for SUPRA. Discussions with local SUPRA users indicated that the product was very favorably regarded. It was stated that application programs need to have only non-logical changes done, since SUPRA supports the existing COBOL TOTAL statements. In summary, SUPRA is a proven advanced DBMS that has a flexible migration path as well as a number of implementation options.

On the application side, the software vendor (SCT) offered an on-line Administrative Inquiry System using MANTIS (the 4GL), which utilizes the technology of SUPRA to access the production data on-line and produces management summary information. Our implementation would be the first in which the SCT products would operate with SUPRA in an actual production environment. It was expected that there would be unknowns, but, with the experience of other sites and the tools available from CINCOM, unexpected problems to be encountered were judged to be a very low risk. Further more, in case of a catastrophic event, there were CINCOM utilities to return us to the original TOTAL environment. As the first site to use this project package, there would be significant vendor (SCT) support also provided.

SUPRA/Symmetry Project

The accounts receivable (ARIS), human resources (HRIS), and student system (ISIS) were to be a part of the migration to the new environment, while the financial system (IFIS) was deferred because it would require both an upgrade to the TOTAL version of the IFIS software as well as a migration to the new SUPRA DBMS. This decision was based on the recent upgrade experience of the human resources system, the first estimate of the project requirements, and the resources available. The upgrade and migration of the financial system was positioned after the completion of the SUPRA/Symmetry project.

The time frame for this project was to begin after the end of the spring term processing (end of May) and to accomplish practically all of the work before the fall registration period (late August).

Framework Planning

Starting at a high level perspective, the project components were identified and then broken down into further details. Due to the uncertainty in a number of areas, flexibility in implementation was to be a keystone for achieving goals - a "framework" project plan.

The major project components were specified and alternatives to achieve these components were laid out. The testing and evaluation of the implementation alternatives were an integral part of the project. Decisions based on these evaluations and recommendations would ultimately determine the final implementation path for each major project component. This approach allowed progress both in the overall project and in the investigation of the implementation details for the project. In a number of cases the work from one project component helped refine the alternatives in another component.

Our first important task to be accomplished was the training, by CINCOM, of the professional staff - data base specialist, systems analysts, analyst/programmers, and data security administrator. The data security administrator was to be the backup for the data base specialist and there were also a number of features of SUPRA that touched upon the area of controlled access and security of the production data.

Major Project Planning Areas

- Staff Training
- Data base conversions
- Program conversions
- Production job conversions (JCL changes)
- Operational modes of SUPRA
- Management Summary Screens (Symmetry products)

Computer Services staff training was a key task and was the first to be accomplished. Analysts and programmers were trained in Mantis, which is the new 4GL and the development language of SCT's Administrative Inquiry System (part of Symmetry). The data base specialist and data security administrator completed the recommended training in the technical aspects of SUPRA.

Data Conversion Paths

Early considerations as to which path to take for migrating the current data touched upon a number of issues, such as ease of accomplishment, assurance of success, and minimum resource requirements. Data conversion considered two aspects - physical data "structure" (or internal schema) and logical data "design" (or conceptual schema). For purposes of discussion in this paper, data "structure" is the physical placement and accessing of the data by the DBMS, while data "design" is the result of a data analysis and normalization process. Only the data "structure" was included in this project, since the data files already existed and the normalization process would be a major project itself. Most importantly, this normalization process did not have to be accomplished in order to achieve the project goals.

Since the data was in the TOTAL data structure, there were CINCOM utilities provided to convert the data to the new SUPRA data structures, which I will describe as "converted" and "native". The "converted" structure was a quick, safe intermediate step, but did not provide the operational performance of the SUPRA native data structure. The path to SUPRA "native" data structure would take much more time and would be more difficult to return to the TOTAL data structure in case of a major problem. Choosing the "converted" path meant that, for the short term, performance of all the data base application systems would be adversely affected and additional tuning would be required.

Operational Options

The IBM 4381 computer used solely for the administrative applications utilizing the MVS operating system and the on-line system software (CICS) presented certain operating limits for implementing SUPRA. It is not the purpose of this paper to go into technical details; however part of the implementation plan did investigate and resolve these technical issues. The following brief discussion will, hopefully, clarify the issues and present the findings from the tests and the final conclusions, which were that SUPRA would operate within the existing computer resource limits and that the selected "mode" of operating SUPRA for on-line applications would be different from the "mode" selected for batch processing.

Only two of the four operating modes for the physical data manager ("PDM") component of SUPRA were considered after initial investigations. One mode is called "central" where only one copy of the PDM is needed for a number of address spaces - in contrast with TOTAL which requires a copy for each address space. On the other side was the "attached" mode where, like TOTAL, a copy resided in each address space.

There was much concern about the CICS region address space requirements for all of the new SUPRA products (Data managers, Mantis, Spectra, other utilities). The only way to increase the current address space limitation of 16 megabytes was to move to the MVS/XA option. This would have been a project itself and would have cause the postponement of the SUPRA/Symmetry project.

Experience at other installations and our in-house testing demonstrated that there was sufficient address space for all the software required. While "central" mode would require higher operating system overheads for on-line processing, less address space would be needed for the SUPRA software packages. For production batch processing, where address space was less an issue, the "attached" mode would be used to achieve maximum performance.

Program Conversions - Major Concern
Conversion of existing production programs was considered to be the area of most concern, since both changed programs and data would significantly increase the effort in testing and degugging. Although SUPRA was a tested product, this would be the first time that these production programs would be put into a real operational environment under SUPRA. From the perspective of the origin and language of the production programs, the following categories of programs were to be investigated and modified as necessary to achieve projects goals.

Program Categories for Conversion

Baseline Programs - COBOL vendor programs substantially unchanged from the vendor's original baseline (SCT)

Modified Programs - COBOL vendor programs modified at the University

University Programs - COBOL programs designed and programmed by the University

Other Programs - Non-COBOL programs written in other languages, such as Easytrieve and Socrates (an old CINCOM product)

All of the programs used in the SCT integrated systems were written for TOTAL and the degree of conversion for running with SUPRA was a major issue. To take advantage of the SUPRA technology for our objectives, only minimal revisions of the COBOL programs were required. Based on vendor information and our investigations, it was determined that about 11% of the approximate 1,100 programs in the program library needed minor changes. The non-COBOL programs proved also to be relatively easy to convert; although the old CINCOM report writer (Socrates) programs proved to be a more of a problem and all of them were rewritten.

Job Conversions - JCL Changes

With utilities that were written in-house, the Job Control Language (JCL) statements were easily changed for all of the production batch jobs, although a few minor problems did crop up. An unexpected benefit was that the library space needed for the JCL decreased by a factor of 5, because the JCL information for the data base files now resided within the SUPRA directory.

The Unexpected - As Expected

As expected there was the unexpected. Many of the unexpected events were positive. The installation of SUPRA and the Administrative Inquiry System went without major incident. Testing of the data conversion utilities and of the restoration of the old TOTAL data structure went relatively smoothly. Address space limitations were not a problem as first anticipated.

There was a handful of exceptional program changes required to accommodate the different handling of certain functions and status codes between TOTAL and SUPRA. Some examples are changing exclusive updates to shared updates, serial read of variable (related) file, and the status code returned with the "RDNXT" (read next) command.

SUPRA is a much more sophisticated DBMS and therefore is more complicated. Data integrity and schema architecture have many benefits; however they do require more resources and longer times in the implementation phase. Although the data base specialist had training as the first step of the project, the actual tasks he was performing were taking much more computer processing times than anticipated. As a result, more judgement was required for assessing implementation alternatives and less comprehensive testing for every phase was possible in the project time frame. Each combination of the alternatives for testing needed significant effort to finish the exploration and analysis.

Independent Major Alternatives

Data Structures - Five Data conversion utilities between the three data structures, (TOTAL, SUPRA "converted" and "native")

Application Job Libraries - Batch and On-line applications for converted and original versions

Data Bases - Two test data bases - "small" and production copy

Modes of SUPRA operation - "central" and "attached"

A judicious pruning of the alternative tree occurred based on vendor recommendations, the experience of other sites, and most importantly our own growing experience. One of the conclusions was that the "converted" data path be selected due to time and risk considerations, although this would imply an initial lower performance level.

Because of the significant lengthening of accomplishing data base tasks, it was evident that the DBMS tuning and population of secondary indices would also take longer than originally expected. However, implementation would occur after the busy periods in the academic calendar so as to allow time for the first round of tuning, which would achieve 80% of the desired results before the next busy period.

Completed Project Paths and Experience

The actual project path was achieved on September 19, when SUPRA was moved into production. The data was converted to SUPRA "converted" data structure; the programs with TOTAL calls were changed where necessary and others rewritten; production jobs had the JCL changed for SUPRA; SUPRA was implemented in the "central" mode for on-line programs and in the "attached" mode for batch jobs. As a result of all the preliminary work and testing, the final tasks of moving to production and verification took 13 hours.

The University's integrated systems have been operating with SUPRA since that time. The move has been functionally "transparent" to the user, which, in this case, was very high praise for a job well done.

Conclusion

The early planning recognized the uncertainties in the project and the benefits of making progress at the same time while evaluating implementation alternatives. The University had a firm foundation of end user expertise, up-to-date computer resources, information system professionals, and a commitment to build upon the information systems investment it had made over the past few years. Key to this effort was the first completed task - training. Subsequent tasks used and built upon this base and the University's foundation in information systems experience. The "framework" plan worked well for this type of project in this institutional environment. If there been time to completely investigate the implementation alternatives, a different path may have been chosen that would have saved time in subsequent tuning and data conversion. The success of the project resulted in the University achieving another milestone along the strategic road to capitalize upon its investment in integrated systems.

Administrative Microcomputing
Roads Traveled-Lessons Learned

David L. Smallen
Director, Information Technology Services and Institutional Research
Hamilton College
Clinton, NY 13323

Abstract: Microcomputing, now a traditional part of the academic computing environment, can also be an important component of the provision of administrative computing services - but there are associated dangers. By following some simple strategies many of the benefits can be realized while minimizing the risks to the integrity of institutional information resources. Such has been the case at Hamilton College. The planning decisions that were made, results that were obtained, lessons that were learned, and disasters that were observed, are useful for other institutions considering desktop computing as an addition to the use of mainframe/mini based systems for administrative support.

The personal workstation, embraced as a productivity tool and heralded by some as the answer to the improvement of instruction, has had a harder time finding acceptance in administrative offices. Among the concerns about micros expressed by those responsible for managing administrative computing services are: loss of data integrity resulting from offices maintaining their own data bases, and the loss of control over the selection of hardware and software with the resulting incompatibility of equipment and data.

While not a replacement for centralized mini or mainframe based systems necessary for shared data bases, microcomputing can provide an important supplement to such resources, and help the institution make more effective use of its administrative computing dollars. Our experiences at one small college provide insight into the potential benefits, requirements, and liabilities of microcomputing.

Historical Perspective

Hamilton College is a private, coeducational, liberal arts college of 1600 students, located in upstate New York. While the institution has many traditions, going back to its chartering in 1812, its history with respect to administrative computing is relatively short. Prior to 1974 all data processing was done on unit record equipment. The punched card was king and data redundancy the norm. The College acquired its first administrative computer in 1974, a 32K machine with 10MB of removable disk storage, which provided batch processing for *all* major administrative offices until 1980 - a truly remarkable feat given the power of the systems that sit on desktops today! During this period the card was still at least a prince, but data redundancy was brought under control.

In 1974, two critical decisions about computing spurred our use of micros. The first was our decision to use the Cornell mainframe (then an IBM 370/168) for large scale academic computing rather than purchase our own mini or mainframe. Not having to directly support such a system we were eventually able to devote most of our energies to integrating the microcomputer into our instructional program. Second, our computing services organization would serve both the academic and administrative computing needs of the College. Thus support personnel developed expertise in the use of micros as soon as they were used in the classroom. Further, advice for hardware and software selection was provided by the same individuals. Table 1 indicates our current distribution of microcomputers in administrative offices.

Table 1
Microcomputers in Administrative Offices

Office	Number of PCs	Office	Number of PCs
Academic Depts*	11	Financial Aid	2
Art Gallery	1	Health Center	1
Bookstore	1	HEOP Office	1
Campus Center	1	Library	6
Business Office	2	Personnel	1
Career Center	2	President's Office	3
Computer Center	3	Registrar	2
Dean of the College	4	Security Office	1
Dean of Students	2	Summer Programs	1
Development	1	VP Finance/Administration	1

*some offices serve several departments

In 1980 Hamilton retired its original batch-oriented minicomputer system and obtained a multiprocessing system, with a view towards going "on-line". At just about the same time microcomputers had gained acceptance by the academic community, with the first applications being simple drill and practice, simulations, and word processing. Even the crudest of word processing systems on microcomputers showed great hope for addressing some of the basic needs of the faculty and administrative offices. But could they do more for administrative users?

Some strategies

While the initial foray into desktop computing was largely experimental and unplanned it soon became clear that managing the growth of administrative personal computers was necessary if chaos was to be avoided. Several strategies were devised to this end. In the remainder of this paper we describe the strategies and the results obtained.

Standardize hardware and software configurations used in offices.

Academic use of microcomputing necessitated a "controlled diversity"[1] of hardware and software, with hardware decisions driven by instructional software needs. This led to the support of three major operating systems MS-DOS, Apple DOS, and the Macintosh. We felt that it was important for data sharing and software support of administrative users that **one** hardware/software configuration be selected for administrative offices. The selection was based on two main criteria: availability of a variety of software packages for word processing, spreadsheets, and file manangement, and the existence of a file transfer and terminal emulation program that would work in concert with our on-line administrative computing system. Based on these criteria we selected the MS-DOS environment, as implemented on the IBM PC.

We selected Multimate for word processing, Lotus 1-2-3 for spreadsheet applications, and PC-File/R for file management. The communications package we used was supplied by the vendor of our on-line administrative system software and features flow control for data transmission, and cursor control for terminal compatibility. Each of these packages was selected on the basis of the criteria of *sufficiency* to meet the needs of most of our users, and simplicity of use. Further, attention was paid to the ease of providing training and support for new users.

The standard hardware configuration is a 640K machine with two floppy disk drives, serial and parallel ports. Users needing mass storage capabilities use the removable cartridge disk technology which provides a simple, and fast built-in backup system. One type of 24-pin matrix printer, one type of full character printer, and one type of laser printer are supported. This simplifies the problems associated with interfacing printers, hardware, and software.

By selecting one hardware/software configuration we simplified hardware and software support activities. Training courses are run periodically for employees and employees trained in the use of the software can move from one office to another and immediately be productive. In addition, the body of trained users serve as an extended support organization - often users can find the answers to their problems by consulting other users. In addition, faculty that use the same hardware and software can exchange information readily with secretaries for document preparation. The existence of a "standard" configuration has encouraged some faculty to make purchase decisions for personal systems in ways that simplify their work.

It should be pointed out that the most important aspect of the above strategy was the selection of **one** hardware and software configuration, not the particular choice of the representatives of that selection. Since the selection period we have had reason to wish that we had originally made some different choices, but we have never regretted the fact that we standardized on **one** system for administrative use.

Simplify the workstation operating environment

Even in an environment of homogeneous hardware and software much can be done to simplify the operating environment of office employees. For example, we built a front-end menu for all users of workstations with hard disks (figure 1). In this way novice users are able to avoid the complexity of dealing with tree-structured directories that are necessary for organizing computer files efficiently. In addition, by maintaining a consistent approach to developing these menus we were able to easily modify them as users licensed additional software.

Sample Menu

1. Multimate Word Processing
2. Lotus 1-2-3
3. PC File III
4. Connect with Cornell
5. Connect with NCR
6. Connect with Typesetter
7. Thinktank
9. Backup Bernoulli Cartridge
0. Return to DOS

Your Choice?

Figure 1

We make extensive use of batch files of operating system commands to minimize complexity for the user. For those users with the floppy-disk based systems we have utilized a start-up disk which contains all workstation configuration information (e.g. printer setup, file setup, clock/calendar access) as well as operating system software. Thus we avoid having to put this information on each software disk and simplify the process of making changes to the workstation environment.

Work diligently to avoid data redundancy

The use of file management software can lead to the propagation of data redundancy as offices attempt to maintain information that is also part of the central data base. For example, an office might decide to maintain its own mailing list of employees. Since there is no direct connection between the two data bases, and each can change dynamically, the inevitable result is a duplication of effort and inaccurate information. How is this to be avoided?

Education is the most important factor in avoiding data redundancy. Offices must understand that they have an interest in keeping the centrally shared data base accurate, and that information to be shared among offices must be maintained centrally. Office-specific information is appropriately maintained on the personal workstation. For example the following data bases are among those maintained on personal computers: parking fines and car registrations (in the security office), work orders (physical plant), computer equipment inventory (computer center), cable pair assignments (telecommunications), faculty publications (library), patient visits (health center). In each case the information in question is primarily of value to the office that maintains it. That office might share information with others through reports, but other offices do not need direct access to that information.

Even in the above examples data bases often contain components of information that are available centrally. How is the office to avoid rekeying that information? We make use of the ability to download information from the central system to the office data base. For example, the auto registration data base must contain the name, ID, residence and class year of each student. This information is downloaded to the data base at the start of the academic year. Then the information about auto registrations, including the assigned decal number, is added to this base of information to provide the necessary data base used in assessing fines for illegally parked cars. Periodically, the security office can provide a list to the billing office of those individuals that are to be billed for fines. The listing contains the ID numbers of the offenders, eliminating the need for the information to be further modified for billing purposes.

Avoid programming applications on personal workstations

We have selected software that does not require users to write programs to accomplish work on personal computers. For example, we chose a file management program that does not require any user programming to maintain simple data bases.

The main problem with user-developed software is the increased potential for undocumented and unsupportable administrative applications. Such applications, if they are important to the operation of an office, introduce a hidden liability to the administrative operation of the institution. Changes in personnel can mean a crisis situation.

However, the situaton would be different if the central computer services organization can provide the programming services and support. Under these conditions the personal workstation becomes merely an extension of central computing services. This was not the case at Hamilton, so we *tried* to avoid such applications.

Some successes

What has been our actual experience with the above strategies in a small college environment? First some modest successes.

The Personnel Data Base

The College has a Personnel Office that is responsible for most aspects of employee relations, including benefits administration, and position management. While our payroll system efficiently processes the financial aspects of the payroll, it is a batch-oriented system that was designed for a different era. It contains a personnel biographical component, and information for any employee can be looked up on-line, but it lacks the flexible reporting capability necessary for our Personnnel Office. For some time we have considered implementing a new payroll/personnel system that would provide this flexibility, as well as additional information management capabilities.

As an interim step we designed a system that was based on PC-File/R. Periodically, usually about four times each year, we download information from our central system to create a personnel data base. Once the information is under control of the file management software, the Director can produce the reports she requires. The system has been successful enough that we have postponed our consideration of a new centralized system for the last three years. Each time we raise the issue, the Director indicates that she does not see a substantial benefit to the new system over the approach she currently uses.

Health Center Patient Visits

Our Health Center handles over 9,000 patient visits each year. In order to plan for the provision of services it is necessary for the Center to be able to collect data on the type of services it provides, in particular, the number of individuals treated for various illnesses and the personnel providing treatment. We developed a PC-File/R application that allows this information to be entered on a daily basis. The Health Center has access to this information at all times in electronic form. In addition, an extract file is created at the end of each month that is transmitted to Cornell's mainframe for statistical analysis. The combination of a PC based application and the monthly statistical analysis provides important information for planning and management of the Center.

Application Packages

Our Campus Center has licensed a software package designed for the room reservations and other aspects of the Center management. The system was designed by a campus center manager at another institution and is now marketed nationally. It is well documented, support is provided by the vendor, and it operates on our standard hardware configuration.

The acquisition of such software is a wise use of funds. Our computer center personnel support the hardware, and other software used on the system, and assist in implementing updates provided by the vendor. The Campus Center was thus able to acquire an application package that we did not have had the time to develop in-house.

Some modest disasters

All things do not work out the way they were planned. Some disasters were also observed during the last several years. Doug Van Houweling's principle that "it is not a bad thing to have a small disaster in progress at all times"[2] is one worth remembering when implementing any strategy.

Incompatible environments

In spite of the best of intentions incompatible equipment sometimes arrives on campus. Our most notable instance occurred when the chair of an academic department decided that the departmental secretary should have the same kind of microcomputer he used at home. He was able to circumvent the purchasing process and the equipment arrived on campus and was used. The secretary who used the equipment was not able to exchange information with other offices on campus, and numerous annoying incidents occurred over the next three years, finally culminating in the replacement of that machine and the conversion of all documents to the standard software (at the expense of hiring a person for an entire summer). The original equipment now sits idle, with only one person at the College knowing how to use it.

Not all incompatibilities in administrative offices arise from deception. Some are the natural result of the need to serve academic departments that use other hardware in connection with the instructional program. Thus we have several academic departmental offices whose hardware/software is other than our standard configuration. In these cases we have developed limited file transfer capability between the machines being supported on campus. The situation is not ideal, but necessary.

The user who knew too much

We had one situation in which a user who had learned some programming decided that he would develop a system for his office. The project required that numerous Basic programs be written. We approached this project with great caution. On one hand we did not have the expertise to develop the applications ourselves on the PC, nor the time to program them on the central system. The application certainly seemed do-able on a PC but we had concerns about the quality of the programming, documentation, and office procedures that would result. The system would replace the data input from our physical plant for our weekly payroll, so there were potentially significant benefits, but also significant risks. We finally agreed to allow the project to go forward as an "experiment" and had the developer incorporate our file manager into the project to eliminate some of the programming. The programming was "finished" over the course of the next year.

The system *was* useful for the office involved. Office personnel were able to more effectively manage the activities that the system was designed to handle even though there were numerous times when programs had bugs that created small crises. The developer soon moved to another office and did not want to continue to maintain the system, and the documentation was non-existent. This resulted in about nine months of difficulty as computer center personnel managed the small crises that resulted. Finally, we spent an entire summer rewriting, and documenting the system, to enable it to be maintained for the future. The resulting system has now worked without a failure for the last 15 months, and continues to serve the needs of the office. The main problem with the current system is that we do not have the time or expertise to modify the system to incorporate new features desired by the office.

Lessons learned

Many lessons were learned over the last five years. We mention some of these briefly. Each of these has implications for the organization responsible for providing computer services.

1. **Avoid the "let the student worker do it" syndrome.** Administrative offices often use students to "do the work". This results in the development of student expertise but not expertise of the employees of the office. Using students in this way is often the easy way out, since many of them do not need extensive training. Of course this is short-sighted on the part of the office manager, and can lead to crises when the student worker returns to the role of student. This is often compounded by not providing the time for office staff to attend computer training courses. The result is that hidden liabilities are introduced into the office operations.

2. **It takes, on average, one disaster before even the most conscientious user will regularly back up data files.** Despite incorporating horror stories into each computer training course we find that even the most cautious of users requires a "personal experience" with losing data files before the concept of backup becomes internalized. A sign that has become popular on campus states "Blessed are the pessimists, for they have made backups". Backup must be continually emphasized and simplified. In addition, computer services personnel should develop experience with the use of "file recovery" utilities.

3. **Microcomputer support needs are underestimated, sometimes dramatically**. Some notable examples include the time it takes to update 35 copies of a word processing package to the latest release; the time it takes to teach users the new features of the upgraded package, and the time spent with the users who cannot attend the training sessions. Standardization does not eliminate the need for support it only makes it manageable. The obvious implication is that staffing needs will be greater than anticipated.

4. **Users' perspective on time changes as they become proficient.** Users forget how long it took to find something that was in a folder in a filing cabinet. They are impatient if it takes more than 30 seconds to locate the same information in a data base containing several thousand records. Remember how long it took to get all the materials together for something you were typing? Now users are impatient if it takes more than 10 seconds to load the document that they were working on when they last left the machine. This will be a factor driving people to faster machines and disk technology. Awareness of this phenomenon is important to help users make sensible hardware choices.

5. **The availability of support services encourages standardization.** This is a variant of the "carrot - stick principle". Most, but not all, users will see the value in using a system that is being used widely on campus. This is the most important reason that standardization simplifies support needs. It should be pointed out that standardization can be more expensive. For example, the standard package may be more expensive than others that do basically the same task. In spite of this, users are usually willing to make the trade off of the cost of a product for the availability of support. The computer services organization must continually emphasize the value of support.

6. **Users must become more independent if support costs are to be managable.** Inherent in distributing the computing power through the use of micros is the need for office personnel to become knowledgable users. As Phyllis Sholtys has said in discussing the role of the office micro user, "There is, however, increased responsibility that accompanies such

increased freedom and flexibility".[3] This does not mean office personnel must become computer experts, but rather intelligent managers of their office computer environment. Users learn much from each other, and they must learn to accept a greater degree of responsibility for their computing than would be the case in a centralized computing environment. The computer services organization must remind itself that they should teach users how to do things for themselves rather than doing things for them.

7. **Printers will be a major source of problems**. Despite a reasonable level of standardization the most technical part of using a software package is understanding how to make the printer do what it should. Hardware reliability is necessary but not sufficient to avoid problems. A large portion of user problems result from not understanding how the printer can be controlled within a software application.

   A mundane but important point that is often overlooked in planning for the office workstation is that sound enclosures are needed for all but the most casually used (or expensive - laser) printers. Failure to recognize this results in a disruption of office operations.

8. **Users will be creative and inefficient**. Computer professionals and naive users don't use computers in the same way. It is common for a user to discover a way "that works" and to continue to use that method even if that is not the "best" way to accomplish that task. An example is the confusion between the use of spreadsheets and file managers. The similarity between the use these two applications for keeping track of information often means that users make the wrong choice, using the software with which they are familiar, rather than the one best suited to the task.

   It is incorrect to assume that because users don't ask questions that they understand what they are doing. A valuable support technique is "support by walking around" to offices and watching what people are doing. It is important in this regard to avoid teaching novice users short-cuts, the use of these "time-savers" invariably will result in an increase in support questions.

9. **Training is a continual support need**. Even with standardization of the workstation environment changes in personnel, upgrades to hardware and software, and the availability of new capabilities necessitates a long term approach to providing computer support. Despite the distributed nature of the equipment, the need for a strong centralized support organization, one that can coordinate training and other support functions is essential. While knowledgable users become an extension of centralized support, their jobs do not depend upon providing computer services. There must be an organization whose responsibility is to coordinate both the centralized and decentralized administrative computer services. A variety of training methods should be available (e.g., audio tapes, short courses, weekly meetings, hands-on seminars).

10. **Office managers should take a leadership role in implementing technology in administrative offices**. The office manager must understand how the technology is being used, its limitations, the training needs, and the possible benefits and risks of the applications being used. Without the involvement of the office head the potential benefits of the technology will not be fully realized.

    In our experience, it has been all too common for the office manager to be a non-user of computer technology. In such cases the office personnel fail to utilize the equipment in the most effective manner to meet the office's information needs. Worse yet, important decisions about the information management needs of the office may be delegated, de-facto, to clerical personnel.

11. **Legal and ethical use of software must be encouraged.** Software copyright laws are not easy to understand, and much incorrect information exists about what is permissible. We have had to continually remind office personnel of their obligations with respect to the proper use of the software that the College has licensed. In this regard it is important that policies for software use be developed campus-wide. We have adopted a policy on software use and have distributed the brochure "Using Software"[4] to all employees of the College. The computer services organization must encourage users to act responsibly.

Recommendations and Conclusions

In order to implement some of the above strategies it is necessary that high level administrative support be evident for them. This requires that a procedure be in place so that requests for microcomputer equipment can be reviewed for consistency with institutional strategies. It must be recognized that this approach will often appear to be more costly, and bureaucratic, but in fact will be more economical when personnel and training costs are considered.

It is inevitable that microcomputers will find their way into administrative offices by the nature of their use in support of the teaching and research needs of the college community. What is important is the way in which their use is managed by those responsible for providing administrative computing services. The application of microcomputer technology in such offices has many potential benefits, and associated dangers. By following some simple strategies many of the benefits can be realized while minimizing risks to the integrity of institutional information resources.

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Lotus 1-2-3 is a trademark of Lotus Development Corp.
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MURPHY'S 1ST LAW AND ITS APPLICATION TO ADMINISTRATIVE COMPUTING

Mary Lawarre Cox
William E. Updegraff
Wittenberg University
Springfield
Ohio

Murphy's 1st law is well known. Its application during the administrative computing conversions at Wittenberg University from DEC/ Quodata/ QDMS/ Archon systems to PRIME/ DATATEL/ INFORMATION/ Colleague systems is chronicled for the unsuspecting and unknowledgeable.

This particular form of Murphy's 1st law is the Gestalt form; i.e. when anything can go wrong in an integrated environment, it will do so exponentially.

CAUSE members should not be surprised to learn that Murphy's 1st Law was well demonstrated at Wittenberg. Its pervasiveness is documented in this paper.

I. INTRODUCTION (Murphy's 1st Law, Corollary I - You will be lulled into a sense of complacency prior to utter chaos.

In the early to mid 1980's, Wittenberg University operated its administrative computing functions in what we believe was an extremely effective fashion. Effective because all administrative systems were fully integrated under a common linked-file data management system, QDMS from Quodata Corporation. All administrative functions were computerized under QDMS; 70% were in-house systems and 30% were purchased. The database permitted production of ad-hoc reports within systems and linked ad-hoc reports across systems without any programming whatsoever. These reports could be formatted automatically or precisely formatted with a user defined page layout. A full-time administrative computing staff of three including one operator/programmer served a user community of 2,346 (2,214 FTE) students, 141 faculty, and 300 clerical and professional staff.

As we learned to use the QDMS resources effectively, we also became constrained due to our Digital Equipment Corporation (DEC) PDP 11/70 memory, architecture, and performance limitations. Within the limits of our hardware and software, we felt we were on the cutting edge. When we reached the point where we could not make or expect significant improvements, we conveyed our concern to the Executive Committee and President and projected replacement of the hardware and software in a progression of 5-year plans. Although funds were not available, we tried to stay abreast of the marketplace just in case.

In the fall of 1985, a series of highly unusual events occurred. First a substantial unrestricted bequest was received by the University. Second, several major offices including Admissions and Advancement had encountered the limitations of our QDMS/PDP 11/70 software/hardware combination and were actively pressing for replacement. Third, and perhaps most importantly, our President was prepared to support funding administrative computing within his round-robin method of dealing with major University capital funds needs.

The preceding optimal circumstances were not known to the Center staff in October 1985. We were "lulled into a sense of complacency and well being."

II. SELECTION PROCESS (Murphy's 1st Law, Corollary II - The better prepared you believe you are, the more likely the resulting chaos.)

A. Driving Criteria and Considerations

In October 1985 with no preamble, the Center was requested to prepare a plan for selecting new administrative computing software and hardware. On November 1, 1985, we suggested five options and a five month assessment period. The five alternatives were:

1. Britton Lee/DEC
2. Information Associates/DEC
3. Datatel/PRIME
4. CARS Information Systems Corporation/DEC
5. Quodata Corporation/DEC

These five alternatives were analyzed by Center staff on the basis of the following four criteria.

C-1. The procurement would be software driven, rather than hardware driven.

C-2. The software was required to be based on a relational or a "near-relational" type of data-base that had a sufficiently flexible report writer to permit end users to produce creative linked reports without assistance of Center staff.

C-3. The software was required to possess a full spectrum of administrative computing applications so that development of in-house applications could be minimized or eliminated.

C-4. The thrust of the application software was required to support decentralized computing with user offices controlling their own destinies as much as possible.

Within one week of our initial proposal, we were requested to narrow the five alternatives to two and cut the evaluation period to two months.

B. Evaluation Process/Departmental Involvement

In addition to the evaluation criteria by the Center staff, statements of needs were developed at University-wide and departmental levels. These needs were used as final evaluation criteria. The final two vendors were then requested to make extensive on-campus presentations to the user departments of the University. The vendor documentation, vendor demonstrations, and information learned from existing vendor customers were used for the final analysis and selection. It had been hoped to make one week visits to existing user sites of the final alternatives but time and circumstances did not permit.

Dr. William Kinnison, Wittenberg's President, was astute in requiring executive level approval of the final decision. While the Center staff assisted in the initial culling, the final choice was made by the users through their representation on the Executive Committee. Hence, the "ownership" of the hardware and software resides with the user departments, not the Center. This was a fundamental departure from previous procurements of the University and fully in step with evaluation criteria C-4 dealing with decentralized computing.

C. Resulting Selection

The final decision was delayed until March 1986. Suffice it to say that a comprehensive contract was signed with Datatel Corporation for both the software and hardware. It is beyond the scope of this paper to discuss the analysis leading to our decision.

The whole evaluation and selection process was chaotic in spite of the continual assessment and study over the years that had preceded the procurement. Hence, Corollary II of Murphy's 1st Law, "The better prepared you are, the more likely the resulting chaos."

III. TRANSITION CONSIDERATIONS (Murphy's 1st Law, Corollary III - It will always be worse than anticipated.)

A. Special Problems in Converting from One Fully-Integrated System to Another Fully-Integrated System

We believe that Wittenberg's conversion efforts are unique in that the University already was using fully-integrated systems linked together by Quodata's QDMS software. This high level of integration has made the transition to Datatel's fully-integrated systems very difficult. Initially, we considered cutting over the whole University with a week's time, essentially shutting down during that period. However, we determined that we didn't have sufficient support staff. Since we had to go piecemeal, work-arounds on both the QDMS and Datatel systems were developed to simulate the integration. The ordering and timing of conversions likewise has been very critical.

B. Physical Connection of Terminals and Devices - Local Area Network

During conversion, users needed to have terminal and microcomputer access to both the DEC PDP 11/70 and PRIME 9955 Model II computers. This problem was resolved by extending the University's VAX-based XYPLEX local area network to both computers. Consequently, users can issue "connect" commands to whichever computer is appropriate during the conversion process.

C. Scheduling (Initial)

Development of the initial schedule for training, conversion and network installation was carried out in consultation with Datatel staff and projected an 18 month period. This schedule was developed as a best guess three months before the hardware ever arrived. Within a few months of hardware/software installation, Center staff realized that at least 2 1/2 years efforts would be required. Meanwhile the Executive Committee was pressuring to reduce the schedule to 12 months. The 250% difference in expectations was potentially disastrous. More will be said later in Section IV.

Hence, the statement of Murphy's 1st Law, Corollary III "It will always be worse than anticipated" is appropriate.

IV. AGONY OR "THE NITTY-GRITTY UNEXPECTED PROBLEMS" (Murphy's 1st Law, Corollary IV - When things seem to be at their worst, they're not, or it's always darkest before it's pitch black.)

A. DEC to PRIME Transition Problems

The PRIME 9955 II computer hardware was installed in mid-June 1986, one month later than anticipated. Datatel Software was subsequently installed in mid-July 1986. Initially, we experienced a number of problems due to a lack of familiarity with PRIME hardware and the PRIMOS operating system. We had been assured by PRIME and Datatel that there would be "no problem" with providing DEC VT-100 terminal capability which was critical because most of our video terminals were DEC VT-100 compatible. While the implementation of VT-100 capability is straightforward in principle, we were one of the first Colleague user institutions to migrate from DEC to PRIME and one of the first institutions to install DEC VT-100 driver interfaces.

A second problem was incompatibility of DEC and PRIME tape utilities. We ended up using custom programs to avoid difficulties.

A third major factor when changing hardware vendors is the loss of staff expertise and the time required to bring existing staff back to expertise levels held on former hardware.

B. PRIME INFORMATION Considerations

The PRIME INFORMATION database which underlies Datatel's software is absolutely superb. However, the database lacks a major feature which has made conversion much more difficult for us: the lack of a formatted or page style report writer. (This should not be confused with the single line per transaction type report writer which is present and is excellent!) Currently custom programming is required to produce paragraph or page type reports (e.g. class rosters, phonathon cards, student invoices). While the technique is relatively straight forward for programmers, it is beyond the capabilities of end users. Since two of the objectives of our procurement were to minimize program maintenance and to place a powerful ad-hoc paragraph-style report writer directly in the hands of our end users, we have been very disappointed.

Offsetting this disappointment was the "Pick" type power of PRIME INFORMATION. We now had variable length fields, multiple-valued fields, and unlimited-length records with the capability of storing lengthy comments.

C. Conversion Calendar Catastrophe

The other problems contributing to conversion were:

1. The lack of a common definition of "conversion" between Wittenberg and Datatel. Datatel's definition was essentially a simple translation of previous data, training on the new software, and cutover. Wittenberg's understanding was different - Wittenberg had the need to reproduce existing functionality without major concern for esthetics. This meant possibly adding bells and whistles to the product if the bell was already being rung by an end-user.

2. Scheduling underestimates. Wittenberg had only one other conversion in its administrative computing history. When Datatel originally suggested 12 to 18 months as being sufficient, we were not in a position to contradict.

3. Staffing Level Problems. Two types of staffing problems occurred. The first was failure of the University to provide a temporary programmer as proposed from the inception of the project. The second problem was the unsuccessful attempt to directly involve all Center staff in the conversion effort. For reasons of better morale, our initial conversion efforts had involved all Center staff. Unfortunately, we could not find adequate time to dedicate to conversion in this mode while continuing to maintain the old systems.

4. Inexperience. Conversion is a unique experience. Since conversion is likely to occur only once every five to ten years, conversion was completely new to most of our staff.

5. Inability to Identify Similar Conversion Efforts. We made very conscientious efforts to contact a sizeable number of institutions about potential problems that might occur during implementation and conversion. Because of our existing level of development, the information gleaned from representatives from most other institutions did not reveal the scope of the necessary conversion efforts.

By December 1986, we had reached the state that we ascribe to Murphy's 1st Law, Corollary IV. "When things seem at their worst, they're not or it's always darkest before it's pitch black."

V. PRACTICAL SOLUTIONS. (Murphy's 1st Law, Corollary V - The more work you do, the more there is to be done.)

A. Picking Up the Pieces

By Fall 1986, Center staff realized that an 18 month conversion schedule was impossible. The Provost was apprised of the situation and informed that a three-year schedule was appropriate to complete a high quality job.

Because of legitimate doubts, the Provost sought and received high level consultation with Datatel to recommend a new schedule and to identify additional resources necessary to successfully complete the conversion. This move was astute and ultimately gave credence to the Center's estimate of a three-year schedule. Besides seeking assistance from Datatel to help develop the revised schedule itself, the University contracted with Datatel for extended services support to provide management assistance, on-site training, and off-site programming support during conversion.

As part of the solution, major changes were made in Center staffing patterns. First, the conversion efforts were almost completely separated from the maintenance efforts. We hired one temporary programmer and reassigned a staff member from systems/network activities to the administrative conversion team. Our staff of three grew to five. Three people were assigned full time to conversion and two people to supporting the existing systems.

The Executive Committee of the University decreed that enhancements by Wittenberg Center staff beyond the functionality already present in the QDMS systems would not be attempted as part of conversion. This lowering of internal expectations in user offices has been a critical factor in the successful maintenance of the new three-year schedule.

Once all of these arrangements were made and implemented, the conversion tasks became possible, albeit extremely demanding and exhausting.

A typical pattern has evolved in all of our conversion efforts:

1. Users are provided with initial documentation about their new system and given access to a trial version of their new software.

2. Center staff study and investigate software, trying to identify relationships between old and new files and fields.

3. Initial training is carried out by Datatel staff at Wittenberg for Center staff and users.

4. Soon thereafter a Datatel representative and Wittenberg staff map old fields and files to Datatel fields and files.

5. Final mapping specifications are sent to Datatel for programming.

6. Users continue to investigate systems and enter code file information in the trial account.

7. After initial version of the conversion program is received from Datatel, Wittenberg staff make corrections

and modifications. Data integrity is carefully checked by Wittenberg staff.

8. Functions and reports not supplied by the "canned" software are put in place.

9. Full conversion is carried out in the test area first. Back and forward links between old and new systems are developed.

10. Conversion is carried out and cutover is made.

11. Cutover problems are resolved. (So far such problems have been minimal and satisfaction high.)

B. Successes!

Full conversions have been completed for Advancement and the Business Office (General Ledger, Accounts Payable and Accounts Receivable). In addition, the Cashier's Office and Purchasing Office have been brought on-line.

C. Future Conversions and Schedule

By the first of the year, we will be live with Payroll and Personnel. Admissions and Financial Aid will be cut/over by the end of January 1988.

Currently, we are planning conversion of Registrars systems in the spring. All basic systems will be completed by July 1988. The last year of our efforts will be dedicated to secondary applications already developed on the old system; e.g. Career Development, Car Registration and Inventory.

It becomes clear that Murphy's 1st Law, Corollary 5 holds: the more we do the more we have to do.

VI. CONCLUSIONS (Murphy's 1st Law Continues but it's still possible to laugh.)

We have proceeded from euphoria (the selection and purchase of new software) to despair (realization that our calendar was unrealistic and staff support inadequate) to cautious optimism concurrent with continual exhaustion. We are confident that we are proceeding in a realistic and attainable schedule so long as our health and morale can be maintained.

We have general advice for other institutions considering switching to new state-of-the-art software and hardware.

Do not underestimate the length of time required for conversion or the additional staff required during the conversion process. One suggestion is to byte the bullet by hiring an external consulting firm to estimate the scope of the conversion tasks, the length of time required, and the staff and financial resources required. We did not do this and made a tactical mistake in not so doing. The analysis permits uniform and realistic expectations to be formed by everyone from data-entry clerks to the president. We could have avoided all the "prophet in one's country" syndrome.

We also recommend that an institution separate its staff resources into a sub-staff responsible for maintaining existing systems and sub-staff responsible for converting/implementing the new system. Existing staff will not be enough. We can assert that temporary staff must be employed.

There are a number of excellent and continually improving packages available. No canned system can supply all of the functionality to satisfy an institution which aspires to excellence and wants to stay at the cutting edge. Therefore, when shopping for administrative software, you've only done half the job when you determine that a vendor's software functionality meets your basic needs. The power of the data base underlying the vendor's products must be examined just as closely. If maintenance of the administrative systems is with an outside vendor and powerful tools are available within the data base, then it only requires a small energetic creative staff to take any college or university to the forefront.

Finally, we want to make a public statement in support of both Quodata Corporation and Datatel, Inc. as vendors of high quality administrative computing software. Our decision to switch to Datatel was complex but based heavily on the lack of available developed QDMS administrative applications on VAX systems at the time of our procurement. Quodata Corporation has very competitive systems and should be seriously considered as a vendor. The Datatel packages that have been converted are working well with performance more than meeting our expectations. The ease of use of the PRIME INFORMATION query language INFORM has been an absolute joy for our end users. In our estimation, the Pick operating system of which PRIME INFORMATION is a variant is one of the most powerful and elegant data bases in existence. It has to be experienced to be appreciated.

We still have much work ahead for the next 12 to 18 months. We still have difficulties but much of the pain is behind us. Throughout the process, we have managed to keep our sanity by laughing at ourselves. In spite of Murphy's 1st Law, we still survive!

LEVERAGING RELATIONAL TECHNOLOGY

THROUGH

INDUSTRY PARTNERSHIPS

PREPARED FOR
THE 1987 CAUSE NATIONAL CONFERENCE
BY

LEONARD M. BRUSH, DIRECTOR
ADMINISTRATIVE SYSTEMS
CARNEGIE MELLON UNIVERSITY
PITTSBURGH, PA. 15213
and
ANTHONY J. SCHALLER, MANAGER
ADMINISTRATIVE SYSTEMS DEVELOPMENT
CARNEGIE MELLON UNIVERSITY
PITTSBURGH, PA. 15213

Abstract

Many higher education institutions as well as software vendors who provide applications software to institutions have attempted to move gradually from conventional file structures and access methods to the technology of data base management system. There have been and are significant impediments to this transition. For the institution a double barreled drawback exists of massive conversion and a staff who for the most part are untrained in and inexperienced with the DBMS technology. The software vendor seems further impeded by the realities of the third generation marketplace. Carnegie Mellon University has chosen to leverage its significant technological expertise with DBMS (particuarly relational) into joint technological and developmental partnerships with a few DBMS and application software vendors. These partnerships have and will result in a base of knowledge in support of the transition to relational data base technology.

DECEMBER 3, 1987

LEVERAGING RELATIONAL TECHNOLOGY THROUGH INDUSTRY PARTNERSHIPS

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THE CARNEGIE MELLON ENVIRONMENT

Computing Intensive

Carnegie Mellon University located in Pittsburgh, Pennsylvania is the home of a College of Fine Arts, a College of Humanities and Social Sciences, the Mellon College of Science, the Carnegie Institute of Technology, a School of Urban and Public Affairs and the Graduate School of Industrial Administration. It not only offers a computer intensive environment to its 6500 students, 400 faculty and 1900 staff but also serves as an intellectual resource for the 1.1 million residents of the Greater Pittsburgh area.

Carnegie Mellon is also home of nearly 4000 University owned computers. These include one IBM 3083, more than 100 IBM PC-RTS, in excess of 2000 IBM AT, XT, and PC class computers; slightly under 100 DEC VAX 8650, 8700, 8800, 11-780, and 11-750 machines; 5-10 DEC 2060s, more than 500 Microvaxes, approximately 200 Sun II and III workstations and in excess of 100 Apple Macintoshes, MAC-SE's and II's. In addition to university owned computers, more than thirty percent (30%) of the student body own their own computers and over forty percent (40%) of the faculty own their own computers. 300-400 computer professionals are employed on campus, many of whom directly support various academic and administrative functions.

Intellectually Inspired

Speaking to new faculty in August of 1987, Dr. Herbert Simon, University Professor of Psychology and Nobel laureate provided an intellectual perspective of Carnegie Mellon when he told the faculty about the computer intensive environment. He said:

"You are all aware that CMU is pioneering in the domain of networked communication as a tool of education. There is an important distinction to be kept in mind here. We do not think of CMU as a computerized campus - though you will see many computers here. I want you simply to understand that the computer network has been built here as an experiment, an experiment in education in which we are all participating. Neither the Administration, nor the Faculty nor the proponents or designers of the system have more than a hazy idea of what its role will be ten years from now at CMU (if we haven't meanwhile torn it out). And its role will be exactly what you make it, or choose not to make it, through your ideas of how it can enhance your teaching and your research. It is an invitation to be innovative."

Carnegie Mellon's innovative and creative spirit permeates many areas of the University. It is this spirit of innovation coupled with the opportunity to experiment with new ways of thinking about solutions to problems that has given rise to the notion of technology partnerships in administrative computing and information systems. The idea is also born from a need. The need exists to provide better information to meet the ever present demands of a changing enterprise. As Dr. Simon so aptly pointed out, "Carnegie Mellon will change in ways not yet imagined." Colleges and universities should use information and the software that drives the production of information as strategic tools of the enterprise with the flexibility to be moved from one operating system environment to another. The portability of software permits the University to take advantage of opportunities offered by the changing technologies. In a Carnegie Mellon University report dated September, 1987 the commission to evaluate the President cited **Information** as one of four primary resources that the President must gather and allocate. Further, the Commission suggested that as an administrator, "the President must govern managerial information."

Administrative Information Systems Environment

The university President and others who govern and administer Carnegie Mellon recognize the importance of flexible and powerful information systems which will enhance administrative processes and provide information as a resource to a broad base of constituents. Executives, administrators, deans, department heads, middle managers, staff and faculty are among the traditional consumers of information to which will now be added students, parents and guardians, corporations, foundations and alumni as well as governmental and legislative bodies.

The recognition of (information) need across a broad spectrum of constituents has led CMU to explore joint efforts with a few commercial firms so as to: (1) develop software which will provide needed information, support new strategic functions and enhance existing administrative functions and (2) multiply the effect of the University's available resources.

Administrative System applications can be found running in somewhat peaceful coexistence on two DEC 2060's; a DEC VAX 8700; three VAX11-780's; an IBM 3083 EX, a 3Com Based, PC Ethernet LAN; several Appletalk networks as well as stand alone personal computers. The current direction is to migrate strategic administrative applications from the IBM 3083 and the DEC 2060's to an integrated, relational database environment operating on a cluster of two DEC VAX 8700's (running VMS) December 1989.

The strategic intent is to utilize state of the art relational data base technology and create advanced systems functionality. For the next few years the administrative information system services, support and development at CMU will be centrally planned, managed and implemented Planning and oversight of implementation by non-central departments will improve the probability success. Recent efforts to design and develop a university information system (UIS) data base and to define the functions and features of student and human resource information systems have provided a model for collective participation, planning and oversight by many university constituents.

The result of the next implementation of administrative information systems will not only provide for distribution of processing and computing, but also provide a basis for distributed data bases. While some enterprises and only a few Universities moved to data base applications in the late 60's and early to mid-70's, Carnegie Mellon developed applications where programs and data were inextricably intertwined, file and data structures were relatively straightforward. We initially were concerned about relational data bases used in intense transaction-oriented applications. The rapidly decreasing price-performance ratio of processors channels and disk storage, however, caused this relative inefficiency to be less of a concern to the CMU information systems planners. Further, the portability of application code and the development productivity are key strategic issues we were unable to overlook.

THE STRATEGY OF PARTNERSHIPS

During Spring 1986 CMU, IBM, DEC and Relational Technology Inc. (RTI) conducted extensive benchmarks of the RTI relational DBMS; the results were extremely favorable. Transaction volumes and response times were measured over a two week period at DEC and IBM data centers. Because of the level of support from DEC and IBM the "benchmarks" really launched the partnership era between the CMU Administrative Systems office and major hardware, database and application software firms.

Following the IBM, DEC and RTI benchmark initiative, CMU felt that some commercial applications software firms would be interested in establishing academic/business relationships and partnerships related to relational data base implementations. Commercially available software was reviewed carefully and these decisions evolved:

- CMU would not attempt to purchase software at full market price but rather would negotiate relationships based on joint participation and resource sharing.
- Opportunities would be explored for joint development, enhancement and/or conversion of vendor-supplied software.
- (Commercially available) software packages which could not be acquired without major out-of-pocket expenditures or which were functionally or technologically inadequate would not be purchased but rather would be designed and developed by CMU staff or jointly with vendor personnel.

The availability of relational data base technology, fourth generation languages, programmer productivity tools and a rich VMS and UNIX development environment at CMU had already proven to greatly expedite the development process. CMU began the process of functional and technological review of existing (commercially available) software. Concurrently, discussions were held with commercial software firms regarding future product directions and interest in the higher education administrative information systems market. Discussions were not confined to firms already servicing the market; new partners were sought and considered. A key part of the strategy was to identify niches where competition was not so stiff nor the market so crowded as to nullify the interest of firms in the market.

Prior to 1986, vendors (except for CARS of Cincinnati, Ohio) of software in the higher education marketplace had revealed no applications based on relational data bases. SCT has since introduced a new product which uses ORACLE as its data base system. The higher education administrative systems software market appeared to be dominated by DEC interactive systems and

IBM (hardware and) batch oriented (operating) systems. The primary market interest in the relational *model appeared to be oriented toward IBM's relational products-DB2 and SQL/DS and DEC's RDB.* In the DEC world, INGRES and ORACLE were beginning to compete heavily with RDB; ORACLE was emerging as a key "relational" player in the IBM marketplace, and for that reason ORACLE was beginning to enjoy familiarity among higher education administrative systems practitioners.

The advantages of such partnerships, we believed, were related directly to the perceived market value of the future products. CMU continued to seek out commercial (software and hardware) partners so as to leverage CMU's technological advantage and perhaps persuade other industry partners to participate in the development of new systems.

Further opportunities may exist for partnerships. Continued evaluation and support of relational data base and distributed data base technologies and investigation of lower cost (parallel) processors as a means of improving relational data base performance at substantial reductions in price performance ratios is also of interest. Discussions with processor firms have resulted in near term opportunities for moving current relational products to parallel processors.

THE RELATIONAL DATA BASE STRATEGY

Why Relational?

With data being stored as a collection of tables in the relational data base, users (programmers or end-users) can combine data elements from different tables to new tables or relations allowing access to relationally stored data. Unlike the hierarchical or network storage organization, the relational model requires little or no knowledge of the structure of the data base. The fourth generation languages when integrated with productivity tools work to facilitate rapid applications development by both "relational" data base programmers and end-users. As in the case of the CMU UIS (University Information System), once the data base was designed the screens and reports were developed expeditiously. The development productivity ratio over conventional PL/1, Fortran and Cobol coding are expected conservatively to exceed 2 to 1 in favor of the relational /SQL applications.

A second major factor in the selection of the relational data base was the portability to a broad base of micro, mini and main frame environments (hardware and software). The value of portability cannot be overstated. This attribute ensures that applications developed on the PC running MS-DOS or the VAX running VMS or ULTRIX or the IBM 3083 running VM/CMS or on the advanced workstation running UNIX will not have to be rewritten to run in these other environments. For the first time applications will not be constrained when (if) different hardware or operating systems environment is dictated. The proof of portability is in the accomplishment: CMU is currently moving two major data base applications from VM/CMS INGRES to VMS INGRES The movement will be complete by February, 1988. The results so far are rewarding.

WHY SQL?

In most organizations, there is increasing desire to standardize on a query language for accessing data. With the design of the relational database structure, SQL was built to enhance access to that structure. In addition to providing a consistent set of semantics for the user, it also was seen as a way to provide inter-database communication between various database software vendors. IBM has finally endorsed SQL as the "official" query language standard for relational database systems. In 1982, the American National Standards Institute chartered the "database committee" to develop a proposal for a standard relational language. This committee, with representation from various (dbms) vendors, are refining the actual "standard". Although not yet in its final form, SQL plays a major role in providing the necessary query tools for clients within the campus to build ad-hoc retrievals against the database.

SQL has been modeled to work well within the relational database structure. Unlike other query languages, it builds upon the same syntactic constructs to build complex queries as well as subsets of data; it is possible to "nest" retrievals for more defined output. Application developers can move from one environment to another without the need for expensive retraining. Applications will become more portable, especially those developed by third party software vendors and can run unchanged in a variety of different hardware and software environments. Since the query language is a standard, it is assured of a reasonably long lifetime.

As data within more organizations are spread across various machine types, it becomes increasingly more important to provide data sharing across those different databases. This task is much simpler if the product (from the same vendor) operates across the heterogeneous systems. In the event of different database vendors, this function has been impossible. Recently however, there is a standard for inter-dbms communication which exists around the SQL standard. Soon, we hope, applications built with tools from one vendor will to talk to other vendor's databases with minimal rewrite and interfacing.

WHO CHOSE CMU? WHO DID CMU CHOOSE?

Relational Data Base Firms

Why INGRES?

With evaluation of various database products on the market, the range of possibilities were narrowed to a few in terms of functionality and operating environments. The requirements were for: (1) A wide suite of development tools would exist within the product (2) a product that operated across MS-DOS UNIX 4.2, VMS, and VM/CMS (3) data and program portability across those systems and (4) a demonstrated commitment to excellence within the product, in terms of regular improvements in function and performance.

The CMU Administrative Systems office chose INGRES as the platform upon which to develop a new suite of administrative information systems for all of the reasons cited above. The development environment possessed robust 4GL capabilities and programming language interfaces (COBOL, C, PASCAL, ADA). INGRES contains an object-oriented approach to all of the internal data dictionary elements which operated reliably, as applications were moved across operating systems. It also provides end user decision support tools. Internally, some development had been done with specific applications based on INGRES and over the past two years with those applications the performance increased 50% with each new release. INGRES provides the ability to separate the applications from the data structures. With various index structures supported, it was possible to tune indices to match the need of the application. Noticeable improvements in performance have been demonstrated.

We feel that distributed database management may be a key to the integration of different computers and operating systems. Distributed database products should simplify data management through software that (automatically) tracks information within a network, allowing universal access to the information, and transferring control of local information to local machines. Distributed database management should impact costs through incremental growth of computing resources. The investment in existing resources can thereby be preserved. We anticipate that the ability to increase transaction rates will occur by spreading tasks among several network nodes. INGRES/STAR for example, is an open architecture design that allows extension to support multiple vendors' hardware, software and networks. INGRES was designed from its inception to support distributed database technology. This initial design approach allowed RTI to install their distributed database product somewhat in advance of the market. INGRES/STAR has separated front-end applications process from the back-end database management software. In this type of architecture, the application asks for data using the SQL database language. This architecture allows addition of a distributed database manager between the front-end application and several back-end databases. INGRES/STAR supports a distributed database manager which allows local INGRES DBMSs to operate autonomously and provides an architectural framework to permit easy access to non-INGRES databases.

Since INGRES is ANSI SQL-based and provides data base gateways to DB2, RMS and other non-relational data base systems, (INGRES) does provide the opportunity for development of industry standard data base systems and applications. The SQL compatibility and the INGRES suite of development and end-user tools provided the incentive for a few vendors to seriously consider joint efforts with CMU.

Relational Technology identified the CMU Administrative Systems office as an organization which could play a key role in the beta-testing and planning effort of the product. An example of this was in the beta-testing performed of their VM/CMS version. CMU provided input as to problems and enhancements needed in the product. This input was received by the developers and quick resolution of problems ensued. RTI's approach to applying engineering changes in this new version, back into the other versions of the product, demonstrated their commitment to excellence in the product.

Furthermore, with the number of heterogeneous operating systems existing in a single geographic location, CMU is an ideal location for stress testing new technology, such as distributed database systems. The campus community was identified by RTI as one in which people sought new technology to provide better solutions to existing problems. RTI and CMU subsequently signed a five year technological partnership for administrative use of INGRES across all systems.

The Application Firms

Student Information Systems

The University selected five vendors of student information systems (SIS) for functional evaluation. Each vendor was asked to present a demonstration of the available software and/or assess the fit against the documented requirements. In all cases, demonstration and discussion (or both) were undertaken to describe the important functional aspects of the package. In addition, the tuition/billing aspects of the vendors' student accounts receivable systems were investigated when those functions were not included in the basic student records software. In technical evaluation, the "as-delivered" version of each vendor's package was considered, as well as the possible modes of conversion of the software for greater functionality in the CMU environment. The SIS vendors selected were: (1) Campus Administrative Resource Systems, Inc. (CARS) (2) EduCon Associates, Inc. (3) Information Associates, Inc. (4) Systems and Computer Technology, Inc., (5) Sigma Systems, Inc.

There was no obvious match for the selection of a student record system (SRS). In each case, there is a significant level of cost and risk associated with each feasible implementation strategy. For example, the RMS/COBOL systems would install easily in the VAX/VMS operating system, but lack the useful features found in relational database systems. In other cases, available relational systems would present serious obstacles to integration of data among the various student systems at CMU. No vendor was including decentralized functionality as specified in the CMU requirements documentation for SIS.

Sigma Systems chose to supply the student aid system to CMU inasmuch as Sigma's goals seemed compatible with CMU goals. Design goals for the Sigma include a heterogeneous operating system environment, SQL-based file access, and maximal functional decentralization.

A partnership has evolved between CMU and Sigma Systems Inc. An agreement to enhance or jointly develop components of student systems is the cornerstone of the partnership. The Student Aid Management (SAM) System, was chosen as a starting point due to the pressing functional needs of CMU and the Sigma interest in a SQL. Some functional changes to SAM and SAR are required to meet the special needs of CMU. A recruiting admissions and enrollment management module will be tailored to the special CMU (enrollment management) needs. The resulting enrollment management module will be more complex than the current Sigma admissions system, ADAM. A registration and student records designed and developed with Carnegie Mellon's unique requirements in mind. A real-time design will result which addresses the CMU functional requirements and with the newly-developed CMU UIS data base design. **Figure 1** is a pictorial representation of an SQL query against the UIS database.

Human Resource Information Systems

A Human Resource Information System (HRIS) project was initiated in April 1986 to develop or install and implement new applications software to serve the multiple HR functions. Personnel and benefits administration, payroll, wage and salary administration, federal compliance, manpower planning, position control and budgeting and applicant tracking were among the modules being sought.

To define the requirements for the new HRIS: (1) a Campus Advisory Committee was created to provide input from the campus community, (2) a HRIS requirements definition document was jointly developed by a CMU Planning Task Force and Deloitte, Haskins and Sells and (3) survey questionnaire was administered to the campus a preliminary set of requirements formed a basis for requirement definition document.

The university plan was to implement the HRIS in the DEC VAX/VMS environment using INGRES. Selected vendors were contacted to assess their interest in a joint venture. This strategy we felt would permit the university to receive significant software license fee concessions in return for development work. The vendor would also provide consulting assistance as needed. Certain functional changes which would require changes to the source code would be incorporated into the vendor's package for marketing and enable CMU to participate in full vendor support including future upgrades.

The three vendors who expressed interest in a joint venture were: Cyborg Systems, Inc., of Chicago, Illinois, Integral Systems, Inc., Walnut Creek, California and Personnel Data Systems, of Philadelphia, Pennsylvania.

These vendors were asked to respond to the HRIS Requirements Document and then were invited to CMU for a presentation. The Planning Task Force prepared evaluations of the vendors and made a recommendation as to whether the university should purchase one of these systems for the new HRIS. Subsequently the planning task force selected CYBORG. The evaluation was conducted on technical and functional bases. The financial negotiations came later.

There were some concerns associated with the selection of Cyborg. The most problematic functional areas are multiple appointment processing and distributed processing with multiple approvals (i.e. "electronic signature"). In the case of multiple appointment processing, Cyborg wishes to include this functionality into a "University module ". Any necessary changes in source code will be made by the vendor. CYBORG and CMU will need to jointly research the problems associated with so called "electronic signature authorization".

The Tool Firms

In developing any new information system, a significant amount of time goes into designing the database as well as required functions. In order to expedite the documentation and design process, various Computer Aided Software Engineering (CASE) tools were evaluated. DEFT which was developed by the company DISUS, Inc. of Rexdale, Ontario, Canada was selected.

DEFT is a product that provides CASE tools not only for database design but also process diagramming and program documentation as well. An object oriented approach is used from system conceptualization to delivery. An added advantage is the interface that exists on top of INGRES by which Entity Relationship Diagrams are used to generate the actual relational database schemas. **Figure 2** is an example from the UIS application. This provides an excellent way to keep both database structures and documentation up to date with minimal redundant effort.

DISUS chose CMU as a partner based on the accelerated CMU systems development plan over the next few years and orientation toward decentralized systems. CMU was thought to be an ideal environment to have the product used as the vehicle by which designs and modifications are communicated across the campus. In addition, based upon our experiences, CMU will advise DISUS about enhancements or improvements needed in DEFT.

Hardware Firms

Discussions continue with hardware vendors where their future statement of direction includes areas of interest at CMU. Early discussions with manufacturers of parallel processing machines, for example, have resulted in the potential for joint development using relational data base systems to drive development of new applications.

Testing of relational data base designs for improvements in both CPU and I/O performance will be one goal. The second goal strikes to the heart of the issue of code portability from one operating system to another. The new parallel processors tend to be UNIX based; current CMU INGRES applications are either MS-DOS, VMS or VM/CMS. The second goal then will be to test the portability of the code to the UNIX operating system.

Other discussions have been held with a variety of hardware firms as new applications appear on the horizon. Some of these applications are discussed in **"FUTURE"** section of this paper. The key strategy here is to explore the best hardware and software solution to the needs of the application and not constrain our solutions by the strategic direction of one vendor.

ENGLISH:

"Provide me with a list of students, their student id, first name, and last name, that are in the course: 15111, section A for the Fall 1987 semester."

INGRES SQL:

```
Select s.course, s.sect, b.pin, b.first_name, b.last_name from schedule s, biomaster b
   where s.course='15111' and s.sect='A ' and s.pin=b.pin and s.semester='F87'
```

BASE TABLES:

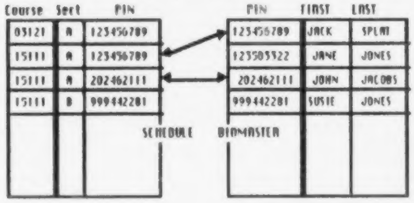
Course
Sect
PIN
PIN
FIRST
LAST
03121
A
123456789
15111
A
123456789
15111
A
202462111
15111
B
999442281
123456789
JACK
SPLAT
123505322
JANE
JONES
202462111
JOHN
JACOBS
999442281
SUSIE
JONES
SCHEDULE
BIOMASTER

Figure 1

UNIVERSITY INFORMATION SYSTEM
SQL Query To Extract Course Roster

RESULTS:

Course	Sect	PIN	FIRST	LAST
15111	A	123456789	JACK	SPLAT
15111	A	202462111	JOHN	JACOBS

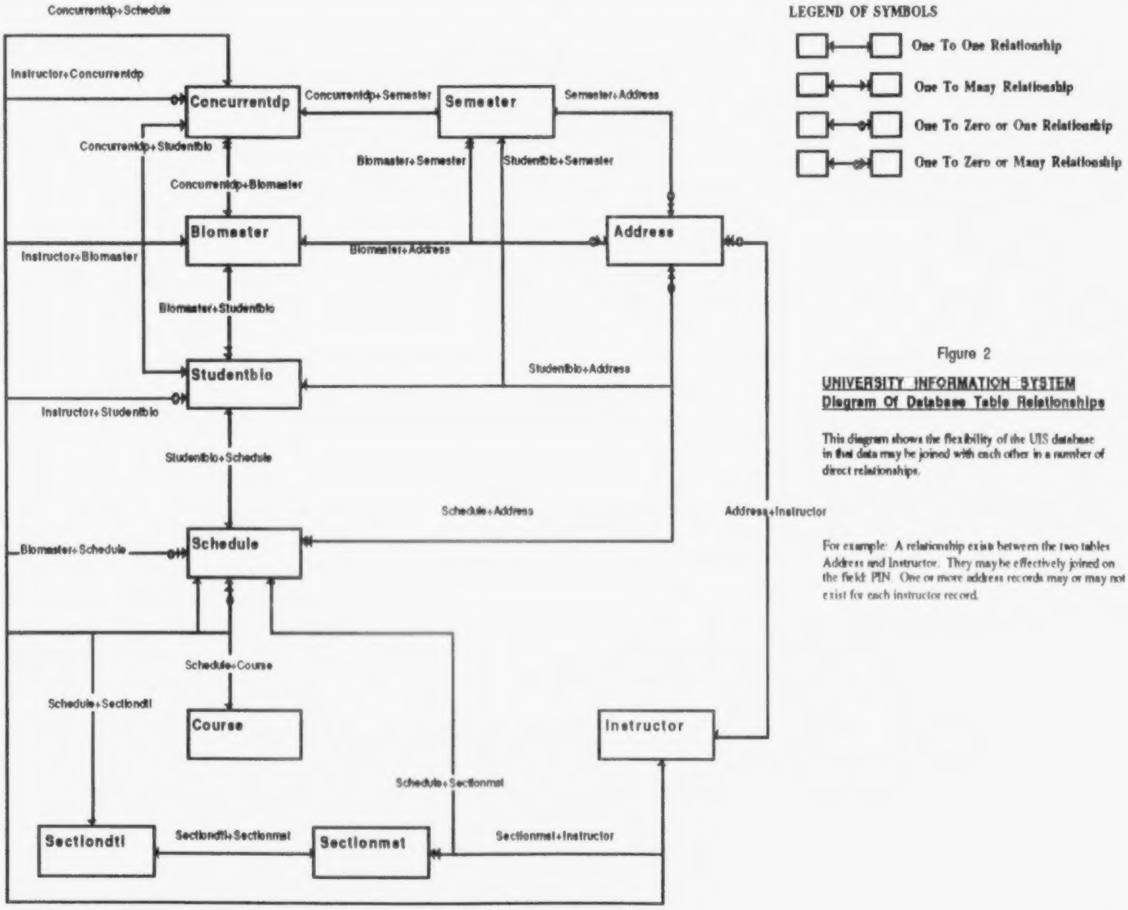
LEGEND OF SYMBOLS
One To One Relationship
One To Many Relationship
One To Zero or One Relationship
One To Zero or Many Relationship
Concurrentdp+Schedule
Instructor+Concurrentdp
Concurrentdp
Concurrentdp+Semester
Semester
Semester+Address
Concurrentdp+Studentbio
Biomaster+Semester
Studentbio+Semester
Concurrentdp+Biomaster
Biomaster
Biomaster+Address
Address
Instructor+Biomaster
Biomaster+Studentbio
Studentbio
Studentbio+Address
Instructor+Studentbio
Studentbio+Schedule
Schedule+Address
Address+Instructor
Biomaster+Schedule
Schedule
Schedule+Course
Schedule+Sectiondtl
Course
Instructor
Schedule+Sectionmst
Sectiondtl
Sectiondtl+Sectionmst
Sectionmst
Sectionmst+Instructor

Figure 2

UNIVERSITY INFORMATION SYSTEM
Diagram Of Database Table Relationships

This diagram shows the flexibility of the UIS database in that data may be joined with each other in a number of direct relationships.

For example: A relationship exists between the two tables Address and Instructor. They may be effectively joined on the field: PIN. One or more address records may or may not exist for each instructor record.

WHAT HAS HAPPENED THUS FAR?

Data Base Development

In 1983, CMU initiated discussions with various database vendors to determine the future directions for each of their products. Specifically of interest to CMU was a statement of direction to develop distributed database systems. After long and tedious investigation, by 1985 RTI appeared to be the only vendor which offered a clear picture as to the problems and issues related to distributed databases; and (RTI) was working on solutions.

In the same year, we acquired INGRES for a VAX 11/780 that was used to build a new space management system. Over the course of the two years that followed, we observed the company to be one which was focused on the improving technology of their product. Performance and function increased dramatically over the next two releases and we found RTI committed to support the product finding and "fixing bugs" with the software in a timely manner.

As the need arose to replace existing production systems, the strategic decision was made to fully utilize the relational database environment. A major effort would include building decentralized, distributed information systems that would persist into the next two decades. In doing so, we would be relying heavily on the vendor to provide a software product which would meet our needs. Due to the technical nature of this effort, the vendor would have to hold an aggressive attitude toward improving the product as well. In fact, as we were pursuing our plan we were looking for partners in technology to work with us over a five year time period. RTI wanted to work with us to insure that our new systems would be successful and necessary enhancements would be incorporated into future RTI products.

CMU has installed new products such as INGRES/STAR and PC INGRES in the past 18 months and will participate in the beta test of a RMS Gateway and the next version of INGRES. As application development has evolved on INGRES, we have continued to identify problems which surface. Many are unique to CMU only because of the large amount of data presently deployed in our database. Support has been excellent in resolving these issues. The database vendor has worked with us to understand our priorities and issues surrounding those problems.

Applications Development

Sigma Systems, Inc., provides software for different computing environments and as a result Sigma development staff have acquired a broad range of experience. The Sigma partnership brings together CMU and Sigma staff who will work to implement new software. This activity is both professionally rewarding and vital for future software product evaluation.

In part because Sigma did not seek to develop its own database management system, did not attempt to design its own screen handing software, and did not develop each installation as unique software, it has been able to adhere to industry standards. The software applications use COBOL, the major data base management systems, and many of the mainframe transaction processors. As new operating system technology is available, the software could be used merely as an adaptation rather than a rewrite of the Sigma application software. New users have been able to implement SQL across different data base systems with a modicum of effort.

Machine Translation (Case 1: COBOL to SQL)

Carnegie Mellon staff have suggested further automation of the software conversion. A machine translation tool was developed by CMU in the course of the SAMS effort in order to expedite the adaptation of COBOL-based systems to SQL. Perhaps one of the most valuable pieces of work to evolve from the partnerships occurred because of the relational technology strategy. As CMU and Sigma began exploration of their partnership, a monumental task emerged of converting large quantities of COBOL code to standardized SQL. To adapt and convert a half-million lines of COBOL code by keyboarding the changes would not have been feasible within the timeframe allocated for the task and the personnel resources which were available at CMU and Sigma. Another tact was clearly called for, even though at the time neither Sigma nor CMU had done the research to explore alternatives.

Clearly some experimentation was necessary and a CMU staff member (Mr. David Campbell) set about the task of finding a better way, not only to do the Sigma conversion but other conversions as well. The strategy of partnerships with vendors of existing software raises among other issues the issue of starting with other people's code.

The basic translator program required about 3 months to write and test by Mr. Campbell and is presently converting COBOL statements to SQL statements at the rate of 250 to 300 per minute; we feel this compares favorably to the approximately 5 to 10 statements per minute using the traditional keyboarding method.

How are the Partnerships Doing?

Relational Technology, Inc.

On June 30, 1986 RTI and CMU signed a five-year (technology partnership) agreement to create a distributed database environment that will span the university's seven colleges. This agreement was the first non-governmental pact to develop integrated information systems based on a distributed database environment that includes a variety of mainframes, minicomputers and personal workstations. The implementation of this distributed environment intends that "end-users" will have access to multiple databases residing on different hardware and operating systems. It is intended that users in one department develop applications and access necessary data and records from remote departments.

A major development effort is complete which integrates student, faculty and financial data within an INGRES database on an IBM 3083. Currently CMU is jointly developing a student information system with Sigma Corporation of Los Angeles and a human resource system (HRIS) with CYBORG, INC of Chicago. These systems will run on a cluster of two VAX 8700's.

The RTI partnership has led to use of the INGRES/STAR distributed database, VM/CMS INGRES and PC-INGRES (an MS-DOS personal computer product) all of which were beta-tested at CMU in 1986 and 1987. The effort will use distributed computing resources of the university, moving data from a central system to departmental systems and to personal systems.

SIGMA

The addition of the recruiting and enrollment modules to the Sigma admissions system should affect those institutions which have the need (and skills) to employ such a product. This development will result in the first CMU administrative system software product which requires more statistical and mathematical understanding than the typical administrative user may possess. This complexity presents a problem of user-training even before the product can be marketed and installed; CMU can play a role in this transition for other institutions.

The CMU student records module is not planned as a marketable software product since the design approach will be somewhat different than at most colleges and universities. Policy and security issues will need to be addressed and resolved on each campus. Many campuses may not be philosophically agreeable to the distributed student record system. Decentralization of authority will dictate functionality and flexibility which may not be needed for most colleges and universities.

At the end of the project CMU will have a student system based on functional designs which may be considerably different than those currently being used and developed. The software and database design must permit modification and extensions. The software will facilitate use of the database management system tools--query languages, report writers, screen generators--which should provide for responsive and productive end-user data processing. A peripheral but nonetheless important characteristic of the partnership is that the software can be maintained by either Sigma or CMU. However a broad market for the CMU student records system will not likely exist.

CYBORG

THE CMU/CYBORG relationship to develop a human resource system in a higher education setting is a much more conventional approach to vendor/client relationships than the Sigma relationship with CMU. It is anticipated the CYBORG Solution Series products will be available with modifications for the higher education market place by late 1988. As implied, the CMU/CYBORG relationship calls for, first, the enhancement of the baseline product and then the conversion from RMS to INGRES SQL data base structures. The main difference from the Sigma relationship is that the relational implementation of

SAM is occurring as the functional enhancements are being introduced. CYBORG is providing consultation and review of requirements which may or may not cause their source code to be modified.

THE FUTURE

Distributed Data Base

Distributed databases will permit us to take advantage of the parallel processing effect which occurs within the software. The query or update command is analyzed by the database optimizer to determine how it may be broken down into queries by location (of where the data is stored). As queries are split into sub-queries and routed off to the processors where each subset of data exists, results can be obtained in parallel and then effectively "merged" together at the requesting node. This would be extremely effective in operations where large numbers of records are changed or several levels of restrictions are applied to obtain a retrieval.

Further work is being done to permit the definition of CPU classes in order to determine effective processing throughput. This will insure that the same processing load is not expected of a small system (e.g. Microvax), as would be a large mainframe (e.g. VAX 8700). In addition, network costs such as bandwidth, routers, and gateways will be weighed into the equation by the optimizer. This will provide further information as to which path is optimal for getting the operations completed in the fastest time possible.

Code Management System

CMU and RTI will jointly work on a code management system to manage software across heterogeneous systems. The two organizations share the objective and task of managing software development across different hardware and operating systems. Especially with some application front-ends residing across many systems (e.g. workstations), and backend software residing on hosts (e.g. mainframes), we wish to have an environment in which new software releases are tracked and installed with standard automated procedures.

New Applications and New Partners

The applications which will benefit from distributed database are numerous. Once the university data has been integrated using INGRES, the applications themselves can be migrated onto the campus network where students, faculty and staff may access them. The initial applications which appear to be likely candidates include:

- **Financial Aid Tracking System** - Here information which is relative to the specialized needs of the Financial Aid Office is kept on a local department system. This local database can contain information such as: interview history data, tracking information, packaging information. The central mainframe systems can hold information relative to awards granted, needs determined, and other data which is more critical to reside on a larger system. Through the distributed database, both of these databases will reside in the same overall database that allows the applications and clients to access information transparently. It aids in isolating critical components of the system without eliminating access. Disk space for information required only by the Financial Aid (FA) department may be used by that department; FA can control the rate of consumption. If all space is consumed, it does not preclude processing which is necessary as part of the overall campus operation.
- **Degree Audit Tracking** - Departments may maintain degree requirements upon their own workstations or local file servers. As these requirements are available, they are used periodically by the central systems for course registration validation or transcript preparation. Locally they provide immediate verification of courses outstanding to students as well as assist in advising students what choices are available in transferring from one program to another. A micro-based, PC-AT, degree audit system application has already been implemented.
- **Student Records Data Entry** - The data entry process for student records information will be moved out of the Registrar's office to the various campus units. By using distributed database to ensure transaction integrity across the network, it will be possible to access translation tables for various validation codes either locally or cached locally after retrieving from the central system. Once data has been entered, the data may be either: (1) stored in a local table, and then updated, applying

the set of entries, against the central database, or (2) updated, in real time, against the production database. Typically one could think of both types of transactions occurring depending upon the time of year.

- **Cashless Campus** - Distributed database can link databases which interface with different applications depending upon the intended usage. With one objective being "debit card" services using a student/faculty/staff ID card, various databases may exist for specific purposes. Food Service will keep information relative to contract meal plans, cash balances targeted toward meals, inventory, and sales transactions. The Campus Bookstore will keep data that is relative to cash balances targeted toward purchase of books and supplies, sales transactions, and inventory. The parking office may keep an authorization database indicating patrons of various campus parking lots. All of these systems will require transaction interface to the Student Accounts Receivable system. It may be possible that the id card technology is used as the ultimate form of authorization granted by an individual to access his/her personal information.

EPILOG

The opportunity to develop a new generation of administrative information and management support systems has been made possible in part by the timely allocation of University seed money. The confluence of recognition by the senior (CMU) administrators of the needs and the opportunities provided by the current (and near future) technology will foster a new and more effective managerial information model.

The technological and economic leverage provided by the adaptation of relational and eventually distributed relational data base systems is pervasive. Creating systems and applications in an environment e. g. INGRES has already reduced the need to completely reprogram or convert applications, if and when new hardware or operating systems are dictated. We believe that large scale administrative applications tend to last longer (2 to 4 times) than hardware systems. The financial and operational advantage of long term application tenure should not be overlooked. Indications are that many application software vendors agree and thus will create more portable applications in the future. Proprietary software/hardware/data base combinations will find niches but not broad markets. With funding provided by the University to create the data base environment and with help from the industry partners in place the momentum exists to create a new generation of administrative systems. As this momentum and its concomitant energy manifest in new applications software, the promise of the technology will be fulfilled having been made possible in large part by the partnerships.

The development and migration of applications and data bases from the central to the distributed environment will be centrally coordinated; the complete migration is expected to span the 5 year period from 1986 through 1990.

Strategies To Implement Technology To Manage and Deliver Educational Programs in a Decentralized Organization

Thomas R. McAnge, Jr.
Virginia Tech
Blacksburg
Virginia 24061

Abstract

The Virginia Cooperative Extension Service (VCES), operated jointly by Virginia Tech and Virginia State University, is pursuing high technology to help meet its mission of providing practical information to the people of the Commonwealth to improve their economic, social, and cultural well-being. Since 1982, VCES has been engaged in a variety of electronic projects to enhance its program management and delivery capabilities. The following are examples of VCES' technology projects, which will be described:

- In 1982, six Extension field offices were connected to VCES' computer network. By 1984, all Extension field offices (120), including offices in all the counties of Virginia, were equipped with personal computers and were linked to the Virginia Tech mainframe.
- C-band satellite receiving dishes were installed at 41 Extension sites during 1987. The teleconferencing system is providing broadcast capabilities for educational programs and staff training sessions from Virginia Tech's campus to the Extension offices across the state.
- VCES began, in 1983, transferring computer files with educational information from the Extension network to a single newspaper. Today, news releases are electronically transferred to six major Virginia newspapers and the United Associated Press, ensuring the printing of timely information.
- In 1985, VCES aggressively began to pursue interactive video as a potential method to expand its audiences. During the next three years, VCES will develop interactive video public information kiosks to be located in shopping malls and in libraries.

VCES' strategy is to stay diversified and try different technologies as they arise. The successful adoption of these technologies has resulted from administration's commitment, staff's involvement, support from other technology groups, using early adoptors to teach and promote, the use of pilot projects, and systematic evaluation. In summary, VCES' plan to integrate future emerging technologies into VCES' program delivery system will be discussed.

Extension Use of Technologies

Virginia Polytechnic Institute and State University (Virginia Tech), a publicly supported, comprehensive, land-grant university, serves the Commonwealth of Virginia, the nation, and the international community by generating and disseminating knowledge in the basic human, social, and scientific disciplines through instruction, research, and Extension. Virginia Tech's land-grant missions are supported by aggressive strategies to develop computing and communications networks. The Virginia Cooperative Extension Service (VCES), operated jointly by Virginia Tech and Virginia State University, is pursuing high technology to help meet its mission of providing practical information to the people of the Commonwealth to improve their economic, social, and cultural well-being.

Since 1982, the Virginia Cooperative Extension Service has been engaged in a variety of electronic projects to enhance its program management and delivery capabilities. VCES' technological projects include a statewide computer network, computer linkages to informational data bases, satellite teleconferencing, interactive video applications, electronic transmission of information to news outlets, computer linkages with other federal and state agencies, and local area networks.

Statewide Computer Network

In 1982, VCES undertook a five-year project to develop a statewide computer network. The network was planned to connect all the Extension field and campus offices to a single computer system.

VCES has 120 field offices--108 county/city offices, six district offices, and six 4-H Educational Centers. Today, each of these offices has at least one standard hardware workstation. The standard hardware configuration includes an IBM-PC with two double-sided 5-1/4" floppy disk drives, a color monitor, a 1200-baud modem, and a dot-matrix printer. All of the PC's are equipped with an AST SixPackPlus expansion board which provides a serial and a parallel port, a hardware clock, and memory expansion. In addition to this standard package, forty offices have an IBM-PC/XT with a 10-megabyte hard disk drive, and 20 IBM-PC portables are being used by area farm management agents. Earlier generation hardware, which remains in use, are 48 full-screen terminals.

All Extension field offices are connected to the Virginia Tech computer system. The telecommunications connection to Tech's mainframe provides all Extension staff with access to the resources of the Virginia Tech Computing Center. The primary computing facility at the Center is an IBM 3090 multi-processor complex.

The majority of the Extension field offices have only one personal computer, and these are typically used for office management functions: wordprocessing, mailing list management, etc. To make maximum use of the personal computers, each Extension office in the state has been supplied with the following microcomputer software packages: YTERM, a communication package; LOTUS 1-2-3, a broadly applicable spreadsheet program; PC-FILE III, a flexible, but inexpensive, data base management program; PCXEDITOR, a screen editor for the PC which resembles IBM's XEDIT editor for its CMS operating system on the mainframe; and WORDPERFECT, a wordprocessing program.

Computer Linkages

Extension has experimented with several methods of sharing computing resources: transferring information from other mainframes to the Tech computer, networking to other mainframes, and networking personal computers. Extension makes use of two nationwide computing systems, DIALCOM and ACRES, by moving information and data to the Tech computer. DIALCOM, owned by IT&T, is a computer network which is used by Extension personnel throughout the U.S. The USDA news releases and OUTLOOK information are downloaded daily from DIALCOM' and redistributed via the Virginia Extension Computer Network. ACRES provides information and agricultural news. It is operated by Farm Bureau.

Recently, Extension has begun to investigate the use of gateways to other computer systems via the Virginia Tech computer. In June 1987, a telecommunications link was installed between the Virginia Tech and Virginia Department of Agriculture and Consumer Services (VDACS) computers. The computer link is a joint project by Virginia Cooperative Extension Service and VDACS. Virginia Tech's Communication Network Services (CNS) Group installed the link and will maintain the communication equipment. The link provides electronic communication between VCES and VDACS computers and the sharing of computer applications.

Extension, using the University's BITNET node, also has electronic mail and file transfer capabilities to the majority of the other land-grant institutions. Presently, VCES is exploring the use of the National Science Foundation and the Southern University Research Association computer networks to share computing resources within the Southern Extension Region.

Local Area Networks

Extension has also experimented with the networking of personal computers. The Chesterfield Extension Office is the site for the 'Computerized Extension Office,' a model office developed to provide information for future computer development. Each agent's, secretary's, and technician's workstation is equipped with an IBM-XT, linked by a local area network. The XT's provide all staff members with sufficient computing power and storage for their own work, and the network links the workstations to a laser printer, a modem to link to the Virginia Tech mainframe, and shared data bases on the other hard disks in the office. The Chesterfield network was installed in June 1986 and a token ring network was installed in the Chesapeake Extension Office in June 1987.

These two test sites are providing valuable information about the usefulness of local area networks and office automation in an Extension office. Due to the success of these two pilot efforts, in the near future, similar networks will be installed in at less one additional office and several less sophisticated networks will be installed in smaller offices to share printers and storage devices.

Satellite Broadcasting

The creation of the Virginia Tech Teleport Facility and the installation of a 9-meter diameter C-Band satellite uplink antenna, in 1986, provided the initial impetus for the Virginia Cooperative Extension Service to explore the usage of satellite technology for information and program delivery. The uplink site presently provides two, broadcast-quality, video signal channels for transmitting NTSC standard television signals from Blacksburg. The vision, and now the reality, of Virginia Tech developing its own multi-purpose satellite communications network affords VCES numerous opportunities to explore the areas of information dissemination and educational program delivery.

In the summer of 1986, approval was given by the Extension administration to fund the placement of 25 downlink sites (at least one per planning district), to be located in local Extension offices, 4-H Educational Centers, district offices, and research stations. Sixteen additional downlink sites were proposed, approved, and became operational in October 1987. Of the 41 downlink sites located across the Commonwealth, 3 are located in district offices, 4 in the 4-H Educational Centers, 4 in research stations, and 30 in local Extension offices.

Using Virginia Tech's television studio and electronic classrooms on campus, VCES began broadcasting teleconferences for Extension staff in April 1987. Presently, an average of four programs are aired each month. Satellite broadcasts from other State Extension Services are also promoted and viewed at Virginia Extension sites. The acceptance and effectiveness of satellite educational programs are being evaluated for the first year to provide future direction for the satellite teleconference system.

Electronic Transfer

The Virginia Tech Extension Information Office (EIO) produces and distributes Extension educational information to newspapers, radio, and television outlets across the Commonwealth. In 1982 and 1983, computer terminals were installed in the EIO Offices. Given this computer capability, the office began to investigate the feasibility of electronic transfer of news releases.

Two major premises were established for the electronic transfer program. First, EIO would try a proactive system; i.e., a system in which new releases would be dumped to news outlet computers, rather than have the outlets access the Virginia Tech computer to select stories. Secondly, news outlets were approached on the basis that a customized service would be provided to meet the outlets' needs.

The service was accepted first by the Roanoke Times, a regional newspaper, and today six major Virginia newspapers and the United Associated Press are utilizing the service. This program guarantees the timely delivery of Extension information.

The EIO Office also electronically provides information to each Extension office in the state via the Virginia Tech computer link. The electronic link offers the EIO Office the opportunity to quickly get information to small dailies, weeklies, and broadcast stations via Extension agents.

Interactive Video Project

A project was planned in 1985 to actively investigate interactive video as an educational tool. The successful development of a demonstration model led to VCES being awarded a $1.2 million grant from the W. K. Kellogg Foundation for the development of public information stations to enhance the information delivery structure of Extension. The three-year grant began April 1, 1987, and employs new technology in information systems that facilitate problem solving. The technology upon which these systems will be based is referred to as "interactive video." This technology integrates large quantities of video, slides, graphics, voice, and text, permitting a microcomputer to coordinate the material for tailored presentations to individuals. Systems based on this technology are good candidates for public information stations because of the vast amount of information which can be stored on the laser disc.

The delivery stations will be located throughout the state in shopping malls and libraries. This setting will provide the opportunity for clientele to receive information in places and at times convenient to them. It is anticipated that, during the first year, 12 stations will be placed in the state, with additional stations being added each of the remaining two years. The systems located in malls will be packaged in such a manner that those interacting with the system will only need to touch the screen to select program options or control the presentation. Systems located in libraries will have the added capability of keyboards and voice recognition.

Program material will be developed in three main areas: consumer questions and concerns; horticulture; and health and nutrition. One area will be developed and tested during each of the three years.

Strategy for Technology Implementation

VCES' approach to implementing information technologies emerged from the development of a statewide computer network which began in 1982. The long range goal was to develop a computer network to enhance the delivery and management of Extension programs. The short-range goal was to meet present demand for computer-aided programs with existing hardware or hardware that was expected to be compatible with the network system and encourage software development by Extension staff.

These goals, developed in early 1982, which seemed very global at the time, have proven to be a very successful formula for implementing technologies for the Extension organization. The following statement from Virginia Tech's, "An Information Systems Strategy," drafted in 1985, describes the approach that VCES and the University has taken toward technology implementation:

> "Classical approaches to planning usually emphasize the establishment of goals. In a time where technology is growing and changing so rapidly, such a static approach is clearly myopic. What seems more fruitful is a strategic view of the University's computing and communication future--a view that attempts to articulate a growth philosophy that permits seizing opportunities when the state of technology is right. Some technological advances are clearly predictable; others are not so easily foreseen. Whatever strategic position the University assumes, vis-a-vis, computers and communication, it must be predicated on foreseeable technological advances, and flexible enough to accommodate those that are not so easily discernible."

VCES' strategy to stay diversified and remain flexible to permit seizing opportunities when the state of the technology was right has enabled the organization to be in a position to implement emerging technologies, but the keys to successful implementation has been Extension administration's commitment, staff's involvement, supportive relationships with other technology groups, early adoptors' participation, the use of pilot projects, and evaluation.

Administration's Commitment and Staff's Involvement

It is well documented that the administration's commitment and the involvement of staff at all levels are critical to any major organizational change. Commitment and involvement are paramount in the implementation of new technology because of the financial resources required, the rapid emergence of new technology, and the dramatic change in staff's skills and behavior required. Conscious steps have been planned and executed by VCES' administration to demonstrate its commitment to technology development projects and a high priority has been placed on the involvement of staff, as illustrated by the following:

- All staff received a letter from Extension's Director which described the statewide computer network as a top priority for the organization and a 25 member task force was appointed to provide direction for the project.

- The first step VCES took toward exploring interactive video was to invite about forty key staff members to a demonstration by a corporation that had successfully developed interactive video for staff training. The enthusiasm for the potential of interactive video rapidly spread throughout the organization.

- The satellite downlink project was announced at an annual staff conference only two days after a decision had been made to move forward with the project. Extension's total staff assemble only once a year. Using this opportunity to announce the downlink project eliminated "grapevine" misconceptions--everyone was told the whys and hows about the project at the same time.

- The strategy of clear communication to all staff at the beginning of a project was also used with the interactive video public information project. The project description and scope were discussed with staff by VCES' Director during Extension's first satellite broadcast teleconference.

Relationships with Other Technology Groups

To support its educational mission, Virginia Tech has excelled in the development of communications systems, computing, and state-of-the-art instructional support services. These advancements have been paralleled by the growth of the University's technology support staff. Extension, recognizing the University's vast resources and resisting the temptation to "go-it-alone," has heavily relied on the assistance from other technology groups within the University. The following are examples of how Extension has benefited from the assistance of the University's communications, computing, and other support groups:

- In 1981, with the plans for an Extension statewide computer network on the drawing board, Extension computer applications housed on a privately leased computer needed to be converted to the University computer system. Virginia Tech's Systems Development Group supervised the conversion of over seventy-five computer programs.

- The Virginia Tech Communications Network Services Department, which is responsible for the University's voice, data, and video communication systems has been instrumental in the design of data communications networks to accommodate Extension's requirements to connect its 120 statewide offices to the University's mainframe.

- The University's Computing Center's User Services staff have conducted training sessions for Extension field staff at off-campus locations. This group traditionally provides user assistance for on-campus graduate staff and faculty.

- With the installation of Virginia Tech's satellite uplink facility, a demand was created for satellite broadcast based programs. The potential for broadcast capability was obvious to Extension with its decentralized office arrangement. At Extension's request, the CNS Department deployed a team to design and install satellite receiving dishes at 41 Extension sites.

- For the past two years, a full-time CNS faculty member has been assigned to Extension to study and implement off-campus voice, data, and video communication needs. As an example of this work, the faculty member has designed and installed two local area computer networks at Extension offices. This arrangement has given the CNS management a better understanding of the University's off-campus communication needs and, at the same time, Extension has benefited from the technical assistance.

- In 1985, when Extension discovered the potential for interactive video to reach new audiences in a decentralized program delivery mode, resources were found within the University's Learning Resources Center (LRC) to assist with an interactive video project. The University's LRC Group had been experimenting with interactive video for several years and generously shared their experiences. Currently, LRC is cooperating with Extension staff on the public information interactive video project, providing video production and instructional design assistance.

- The LRC staff are also very involved in Extension satellite programming. The programs are aired from the University's studio or electronic classroom and are produced by the LRC staff.

Participation of Early Adoptors

During the implementation of Extension's statewide computer network, there was an obvious shortage of staff to conduct training and provide daily user support. With limited resources available, Extension elected not to make significant staff additions. One faculty member was hired to coordinate training, but hardly one person could have been expected to provide training for staff housed in 120 different offices across the state. The lack of users' support created frustration for the staff, but over time an informal learning network developed. The early adoptors of computers did not wait for additional formal training, but resorted to self-instruction and user groups to expand their knowledge of computers. In short, with the leadership of these early adoptors, staff organized themselves to deal with the void. Extension realizes the existence of early adoptors within its organization and other organizations and uses these resources, illustrated by the following:

- One of the major problems with a decentralized computer network is the logistics of providing training and other support functions. To address these problems, Extension has identified staff within the off-campus offices to assist with training, equipment installation, resolving software problems, and, in general, promoting computer applications. These staff include secretaries, Extension agents, and faculty. Typically, these staff members were the early adoptors of computers and self-educated to become computer literate.

- In most cases, Extension's technology pilot project sites were selected because the staff at those chosen locations had reputations as early adoptors. Using early adoptors for pilot projects minimized the effort required to deal with resistance to change.

- The Extension Computing Resources Office uses early adoptor staff to test newly developed software.

- For each satellite downlink site, a programming coordinator was identified. Staff were selected as coordinators based on their reputation as innovators. The coordinators roles are to: identify audiences, actively promote satellite broadcasted programs, involve other staff to expand the appreciation for the delivery method, and create a total educational program around each broadcast.

- A computer link was successfully established between Virginia Department of Agriculture and Consumer Services and Extension, because the staff from both organizations involved in the project could see the potential for such an electronic linkage. A conscious decision was made to avoid staff that would construct barriers, resisting the technology.

Use of Pilot Projects

Pilot projects have been used extensively by VCES to test emerging technologies and positions the organization for full-scale implementation. In addition to the obvious benefits of pilot projects, VCES has seen that pilot projects heighten staff awareness of new technologies, visibly demonstrate the administration's commitment to new modes of operations, and prepare staff for future change. Pilot projects also permit the organization the option of abandoning a technology if it doesn't develop as anticipated. The following are examples of VCES pilot projects:

- VCES' statewide computer network began with six offices equipped with computer terminals and dial-in capability to Virginia Tech's mainframe. The pilot project readily identified problems associated with a decentralized operation--equipment delivery and installation, telecommunications problems, staff training, and hardware maintenance. On the positive side, the benefit of electronic communication of timely information, the usage of a hi-tech office, and the increase in staff morale were observed.

- In 1982, VCES purchased several multi-user and personal computers and tested both systems in field offices. Although, at the time, the multi-user microcomputer seemed the reasonable approach, the 'PC' emerged as the standard. VCES was in a position to move rapidly and implement PC based systems.
- With the widespread use of personal computers and the abandonment of multi-user micros, VCES installed a PC network in one Extension field office in 1986. The pilot project allowed VCES to identify how local area networks could benefit the local offices' office management and program delivery computer operations. Also, the experiment yielded a working configuration that could be replicated. The success of the project was recognized by another Extension field office which obtained funding to install a network patterned after the pilot configuration.
- Extension's use of interactive video systems for information delivery began with the development of a demonstration model. The model was used to evaluate hardware and software components, but, more importantly, the model demonstrated to staff the concepts of the merging of computing and video technologies. Having successful demonstrated the potential of interactive video with the pilot test, private funding was obtained to fully implement several public information systems.
- This summer a telecommunications link was installed between the Virginia Tech and Virginia Department of Agriculture and Consumer Services (VDACS) computers. The first computer application where both agencies computers will collect and share data is not expected until January, but there is already growing interest in additional applications using the linkage.
- A pilot project has recently been started with desktop publishing. The purpose of the project is to develop operating procedures for regional desktop publishing. The project will include testing methods for electronic routing, evaluation of desktop publishing systems, determination of training requirements, and documentation of staff acceptance.

Evaluation

The Extension organization, national and state, places a high priority on evaluation as part of the program planning process. All Extension staff annually develop plans of work, which includes planning, implementation, and evaluation components. Likewise, Extension's technology projects have included evaluations:

- An initial step in Extension's computer project was to conduct a needs assessment. The study focused on the question, "How can computers increase the organization's effectiveness and efficiency?" The results of the study have been, for five years, to set priorities for computer equipment and software.
- Evaluation results have been use to justify expenditures for technology projects.
- One-quarter of a faculty position has been assigned to Extension's public information project to evaluate the project.
- An extensive evaluation, using qualitative methods, was conducted of the local area network project. The evaluation tracked staff's reactions and behavioral changes.
- Currently, a study is being conducted to determine how staff are using electronic mail. The results will be used to assist staff in their determination of appropriate communication methods.

Future Plans

For the past five years, VCES has taken a diversified approach to implementing emerging technologies and has maintained a flexible position in order to expand its use of proven technologies. Realizing the vast number of technological advancements on the horizon and not willing to be content with past successes, VCES organized a task force last Spring to develop strategies for implementing emerging technologies. On November 18, 1987, the committee's report was presented to the Extension Administration. The following is a summary of committee's recommendations:

Needs Assessment - Some would say that VCES has been driven by new technologies-- installing hardware and then asking the question, "How can this technology be used?" In order to seize opportunities, VCES has moved quickly to implement several technologies. Now, with a variety of program delivery methods in place, VCES must determine informational needs and preferences of clientele, and assess current and future information delivery methods to determine their appropriateness and effectiveness.

Resources Networking - VCES has just recently began to investigate linkages with other computer systems, but already recognizes a great potential for sharing resources. VCES will continue to pursue computer links with other agencies, institutions, and organizations for sharing of information and data bases. VCES will also actively explore strengthening relationships with other agencies to foster the cooperative efforts in research, data collection, and standardized information delivery mediums.

Information Delivery Systems - Emerging technologies are rapidly changing the way we think about delivery of educational information. Extension should continue to develop, implement, and evaluate electronic systems to increase program delivery capabilities, efficiencies, and effectiveness. The greatest challenge will be the establishment of standards and coordinated procedures to permit the employment of multiple approaches to information delivery.

Knowledge Base Systems - Computer-assisted instruction (CAI) and computer-based training (CBT) are an integral part of many organizations, providing alternatives to training personnel at a distance. Also, computer technology offers new options for diagnostic services, potentially replacing one-on-one personal contact services. The potential for successful computer-assisted instruction and knowledge systems within VCES are numerous, yet minimal effort has been devoted to this area. systems. As an outgrowth of VCES's interactive video, increased activities are expected in the areas of laser disk and expert systems.

Staff Development - Two major challenges exist for Extension related to staff development and emerging technologies. First, programs need to be expanded to maintain staff's competency in applying various technologies. Secondly, VCES should utilize the appropriate technologies in providing staff development opportunities.

Capital Budget - For the past six years, VCES has had a modest capital budget for technology projects. Today, the number of technologies competing for those dollars is increasing. VCES should establish capital budgets to recognize the fiscal demands required to maintain a diversified and flexible position. And, VCES plans to develop a procedure for prioritizing capital expenditures and allocating development funds.

Organization Structure - The present VCES technology support groups have evolved over the years without serious considerations being given to the organizational structure required to support emerging technology projects. An organization should be put in place that complements the incorporation of new technologies. Responsibilities for development, implementation, support, staff development, and evaluation should be clearly defined.

Summary

VCES, like many organizations, is at a crossroads related to the implementation of technologies. Many of the questions related to computing and communications are much clearer than in the past. The majority of the computing needs for Extension can be handled by personal computers or networks of personal computers. Computer linkages to centralized mainframe computers can provide the major computational services and repositories for information data bases, at least for the short term. Communication networks are in place; although, separate and relatively expensive. We are now in an information era with technologies merging to create information systems - incorporating activities in computing, communications, data bases, and new data storage alternatives.

Any strategy for the future needs to consider how communications and storage media technologies will advance and how they will be integrated. Information systems strategies will force decisions regarding how information will be stored and retrieved.

The development of strategies for the future technologies in VCES will start by addressing the following questions:

- What methods of information delivery are acceptable to staff and clientele?
- To what extent should voice, data, and video communications be merged?
- What is the future for two-way video systems?
- Where should information be stored?
- What are the cost considerations for communication systems compared to decentralized information data bases?
- How can decentralized data bases be updated?

The answers to these questions are expected to direct VCES to a flexible position for technology implementation for the next five years.

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FOURTH GENERATION LANGUAGES IN A PRODUCTION ENVIRONMENT

Sharon P. Hamilton, Ph.D.
Associate Director, Computing Services
San Francisco State University
San Francisco, California

SQL and DB2 are touted as the productivity tools to cure the "ills" of long application development cycles and of user-unfriendly software. Relational database management packages which use 4GLs are said to "have come of age." But where are the large applications in production today to verify or to demonstrate the stated advantages? This paper:

(1) explores the literature for and against 4GLs;
(2) describes several large applications written with 4GLs;
(3) details the San Francisco State University experience of creating a Student Financial Aid application using ORACLE, a relational DBMS which uses SQL.

Both hardware and software aspects of the new development tools will be discussed.

FOURTH GENERATION LANGUAGES IN A PRODUCTION ENVIRONMENT

INTRODUCTION

During the last few years, much of the popular MIS literature has focused on software methods to increase data processing efficiency and information availability. Terms such as "fourth generation languages," "user friendly interfaces" and "database management systems" have been thrown about, often in the same paragraph as references to 30:1 improvements in programmer productivity.

This paper first presents a commonly used framework to explain "what the shouting's all about." From that foundation, it next focuses on the use of one 4GL, the Structured Query Language (SQL), by two relational database management systems, DB2 and ORACLE. Specifically, the extent to which these software packages are being used in a production environment in both industry and in institutions of higher education is explored. Finally, the ORACLE implementation of a Financial Aid system at San Francisco State University is described in detail.

WHAT IS A FOURTH GENERATION LANGUAGE?

The 4GL attempts to solve many of the problems of the traditional application development cycle. "Third generation" procedural languages such as COBOL, combined with file structures such as ISAM and VSAM, have been the work horses of DP shops for more than a decade. Unfortunately, the development cycle for a 3GL application is quite lengthy, and is not easily accommodated to changing user requirements.

For the purposes of this discussion, the important elements of a 4GL are:

(1) a database management system (DBMS);
(2) a data dictionary;
(3) a query language;
(4) a screen/report generation facility; and
(5) a programmer's "workbench."

(1) A DBMS. The first item on the above list, the DBMS, is critical to the 4GL because it allows data relationships to exist independently of applications and facilitates data

sharing with concurrency control. The DBMS thus allows application developers to concentrate on products more than on the physical structure of the data. Users access views of the data, also controlled by the DBMS.

Two models are common for DBMS packages: hierarchical and relational. A hierarchical DBMS, such as IBM's Information Management System (IMS) or Information Builder's FOCUS, presents data to users in a tree-like structure. To the user, each record resembles an organization chart; the top level is known as the "root" which identifies the record and may contain the most commonly accessed information in the record. Lower level segments of the record ("child" or "dependent") contain some set of data elements that are logically related to each other.

The hierarchical model allows variable-length records consisting of one root segment plus any number of dependent segments. The DBMS accomplishes this flexibility by using a set of pointers, chains, physical positioning, directories and bit maps that indicate connections. It is up to the data base designer to establish physical data base representations that result in processing efficiencies, to group data elements that are logically related, and to create segments by considering how data will be accessed by application programs. Paths, or logical views, are defined by the types of data base segments that can be accessed and by the kind of access that is permitted, such as read only, read/write, etc.

The two major advantages of the hierarchical model are: (a) it is a well established concept and implementation, and (b) it handles large volumes of data efficiently. The major disadvantage is that the supporting data structure is inflexible and requires substantial planning for optimum performance.

The relational DBMS, such as IBM's DB2 and Oracle Corporation's ORACLE, presents data to users in the form of tables of rows and columns. This is a more user oriented view. The user is isolated from the physical storage of data. A table consists of one record type, housing a fixed number of fields. There is no explicit sequence by which rows (records) within a table (file) are organized. A set of tables can be accessed by specifying relationships between tables in order to develop useful sets of data.

There are three basic operations that a user can specify in a relational data base: Select, Project and Join. In each, one or more tables are manipulated, resulting in the formation of a new table. The Join operation best illustrates the power of a relational DBMS. It takes full advantage of the segmentation of data into usable pieces (tables) that can be retrieved and combined when necessary. The user then extracts information of interest from a table containing "joined" elements from database tables.

Flexibility is the major advantage of the relational model. It can easily adjust to changing information requirements. Unlike hierarchical DBMSs, relational data bases are not built with a limited number of logical views or access paths. Their access paths are specified by the user. This flexibility contributes to the major drawback of this model, which is performance. Users may not select the optimal access path, and may not state their data requests in the manner most efficient for the DBMS. The DBMS must do more work for the user, which impacts the performance of this type of data base.

(2) A Data Dictionary. The data dictionary is a mechanism for defining data attributes and establishing relationships between data items. The data dictionary serves the important function of specifying, in a central location, such things as the types of validity checks that have been applied, who has update rights to the data item, security levels imposed and other names by which this data item is known. These attributes of the data item are provided when placing it in the data dictionary.

(3) A Query Language. A high level query language is generally defined as a user-oriented facility for the creation and retrieval of data in a data base. Extending this further, a high level query language also provides transparent navigation of a data base as well as a "natural-language-like" qualification of the query. SQL, the Structured Query Language that is the main interface to both IBM's DB2 and Oracle Corporation's ORACLE, has been accepted as the American National Standards Institute (ANSI) standard database manipulation language.

(4) A Screen/Report Generator. A 4GL must be able to paint screens and generate reports with ease. The screen painting facility allows the creation of appropriate display screens for the entry and/or presentation of data or information. A report generator provides similar capabilities for information derived from the data. These features should not be dependent on an application generation tool; they should allow access to data stored or to be stored in the data base without the need to generate application code.

(5) A Programmer's "Workbench". This component of a 4GL environment contains tools to increase the cost effectiveness of programmers. Commonly, a "debugger" for researching code errors is among the utilities in the workbench. Code generators have been another major innovation. Application development systems, the next logical step, allow the construction of entire application systems or subsystems using "canned" subroutines that have the potential of cutting coding time by forty percent. Finally, the ideal 4GL also includes a tool that improves the production of system and user documentation. The combination of the data dictionary and the right tools from the programmer's workbench can virtually automate the production of documentation.

WHERE ARE THE SQL PRODUCTION SYSTEMS?

As was mentioned in the Introduction to this paper, only two relational database management systems using SQL will be discussed here. A general description of the requirements of each product, DB2 and ORACLE, is given below.

IBM released its relational DBMS product, DB2, in 1983. Judged by the industry to be a "relatively lackluster" DBMS offering since 1983, IBM announced a new release of DB2 in 1986 which improved its performance sufficiently that IBM repositioned DB2 as its broad-based, production-level database management system. The products which define DB2 include:

(1) Structured Query Language (SQL);
(2) Data Extract (DXT);
(3) Query Management Facility; and
(4) Utility programs that facilitate workstation access.

To implement these four products, operating system releases must be carefully synchronized. For example, DB2 requires MVS/SP Release 1.3 or MVS/XA release 1.2. To use the Query Management Facility, GDDM Release 3 is required. If CICS is to be used, then its Release 1.6 is required.

To estimate the storage space required for a DB2 implementation, Walsh (1987) recommends: "Determine how much it costs to store information in existing data base structures or files and simply triple that amount for the number of months it will take to complete the conversion...the rule of thumb is that a DB2 data base requires twice as much space as an equivalent sequential file."

The ORACLE product has been available since 1979. Its first release by Oracle Corporation of Belmont, California, was based on the IBM System R, SQL. In 1980, ORACLE was rewritten in "C".

As of 1986, ORACLE had been ported to about twenty different minicomputer vendors' hardware. It has been cited as having 14.6% of the minicomputer DBMS market, thus making it the number one vendor of same. The development machine for the ORACLE product is the Digital Equipment Corporation's VAX minicomputer.

ORACLE has recently been migrated to different sized hardware -- mainframes and microcomputers. ORACLE is marketed as a user's DBMS, and uses SQL consistently throughout all its modules. As of Release 5, the modules which comprise ORACLE include:

(1) SQL (for data definition);
(2) SQL*Plus (for report writing and user queries);
(3) Pro*ORACLE (for 3rd generation language interfaces);
(4) SQL*Design Dictionary; and
(5) SQL*Forms (for screen painting and online processes).

Oracle Corporation's decision to rewrite its package in the "C" language has eased portability of the system. As systems programmers upgrade operating systems for users, however, there must be careful synchronization of the "C" compiler for ORACLE so that SQL statements perform in a standard fashion.

As with DB2, ORACLE users notice that, as the complexity of transactions increases, response times slow (see discussion below). This performance issue is also well known to vendors of third-party software which use ORACLE. In response, both IBM and Oracle Corporation are beginning to discuss microcode implementations of their product in future releases. This "turbo" feature bears watching as large production systems are developed.

DB2 Use in Industry. In a 1987 Datamation poll of IBM customers (Carlyle), many corporations developing large-scale production systems in DB2 are "reluctant" to discuss them. The IBM Guide user group claims that over a thousand DB2 licenses exist in the United States.

Seven large-scale operations which have been quoted as using DB2 in a production mode are:

(1) DuPont;
(2) Travelers Insurance Companies;
(3) New York State Retirement Systems;
(4) Metropolitan Life Insurance Company;
(5) U.S. Navy Retail Logistics;
(6) Deere and Company;
(7) St. Paul Companies (medical liability insurers).

DuPont employees refer to its use of DB2 for "strategic" aspects of the corporation. Travelers Insurance is on record as using DB2 for its "strategic" Customer Information File. The New York State Retirement System was a DB2 beta test site in 1984, and currently quotes a database size of between 20 and 30 gigabytes. U. S. Navy Retail Logistics is creating a large-scale DB2 prototype to test Texas Instruments software which automates the systems design process.

Some statistics are available from these agencies regarding performance measures. The New York State Retirement System, for example, has quoted ten database calls per second with response times below three seconds. Deere and Co., by contrast, has noted that as transactions become more complex, response time slows significantly.

Charles Schwab and Company performed a DB2 benchmark (_Computerworld_, 1987) which found DB2 limited to 18 transactions per second (tps) for their application. IBM quotes a 47 to 50 tps for production purposes. The source of this discrepancy, according to Schwab officials, is the record locking mechanism used within Release 2 of DB2: "...with 100 terminals, the locking became so extensive that DB2 crashed, along with CICS."

DB2 Use in Education. The OASIS project, a research and development project currently underway by a consortium of IBM, Information Associates (IA), and three campuses within the California State University System, has been approved to rewrite the IA Series Z software to operate under DB2. This is the only DB2-based production project within institutions of higher education discovered by this reviewer. The three campuses, CSU-Long Beach, CSU-Los Angeles and CSU-San Luis Obispo, have only begun the conversion of "Series Z" (currently written in COBOL) to SQL and DB2. Completion of the OASIS project is scheduled for 1990.

ORACLE Use in Industry. Although the ORACLE product has been on the market since 1979, none of the technical/trade periodicals reviewed by this author carried articles regarding its use in industry. The publications of computer users' groups, however, did lead to several applications based in the ORACLE DBMS package. Three will be discussed here: (1) Byer of California; (2) Fritzi Corporation; and (3) Solomon Brothers.

Byer of California and Fritzi are women's clothing manufacturers. The ORACLE DBMS is used by Byer for data definition and entry for their order processing system. Fritzi Corporation also uses ORACLE for their order entry and billing system. Both manufacturers are running their systems on Prime minicomputers. Screen definitions are not considered complex, and no performance problems have surfaced. Neither company is presently using SQL*Forms for screens in the production environment, but both are in the process of developing them. SQL has greatly enhanced their programmer productivity; both have fewer than ten programmers supporting their applications.

Solomon Brothers, the financial management firm, as of the summer of 1987, uses the ORACLE DBMS in a production mode on four of its Prime minicomputers. They have also installed SQL*Forms on a fifth Prime, and are in the process of developing screen-based systems.

ORACLE Use in Education. During the past six months, several medium-sized universities have either implemented or begun development of ORACLE-based administrative software systems. The State Universities of West Virginia, for example, are beta testing the student information system package offered by Systems and Computing Technology, Inc. (SCT), which has just been rewritten in ORACLE. California State Polytechnic University, Pomona, has begun development of its student applicant system in ORACLE on a Prime minicomputer. A large university, San Francisco State University, has developed a Financial Aid application using ORACLE Release 5. This development is discussed next.

A 4GL PRODUCTION SYSTEM AT SAN FRANCISCO STATE UNIVERSITY

In June, 1987, San Francisco State University received its copy of ORACLE Release 5 for installation on a Prime 9750 minicomputer. Three months later, the ten-year-old (previously COBOL batch) production system was rewritten into an ORACLE database system, complete with online screens, reports and documentation. In January 1988, the system goes into test production in parallel with the old version, processing transactions from approximately 25 terminals. The test includes two new application modules beyond the scope of the original Financial Aid system.

San Francisco State University (SFSU) is one of the nineteen California State Universities. With a headcount enrollment of 26,000, SFSU's Financial Aid recipients number over 8,000. The decision to experiment with a relational database management system for development of a Financial Aid application was strongly influenced by a grant of the ORACLE DBMS product from Prime Computer, Inc. The quoted cost of ORACLE Release 5 exceeds $40,000.

Among the great benefits of this development are user satisfaction and greatly enhanced programmer productivity. User requests for changes to tables (via the data dictionary) and screens can be implemented, for example, in less than a day. Among the drawbacks experienced by SFSU are costs of hardware upgrades and already visible response time degradation.

During the four-month prototyping phase, SFSU has upgraded its hardware support for ORACLE Release 5 from a Prime 9750 with eight megabytes of central memory to a Prime 9755 with 14 megabytes of central memory. Prior to the upgrade, the four-person analyst team could "freeze" the minicomputer and bring down ORACLE by running four simultaneous processes. Counts of page faults per second during this test exceeded thirty.

Since our main student information system is on a different computer, we use a combination of SQL and COBOL to load and update the Financial Aid tables. This procedure currently requires over four hours of nightly batch runtime by the ORACLE system.

Our most complex screens (developed using SQL*Forms) contain over 80 background processes. We have experienced up to ten second delays while ORACLE processes screen input, runs a background COBOL routine (a third party Needs Analysis program), and returns the results to the screen. The Student Financial Aid Budget and Resources screens, which contain complex computations within SQL*Forms, have taken twenty seconds to paint with four users accessing the application.

The Financial Aid office users, however, are ecstatic with the result of this prototyping experiment. In addition, all programmers within Computing Services are anxiously awaiting their opportunity to develop an ORACLE production system. Management within Computing Services is delighted with the ORACLE solution to the system documentation dilemma as well as with the short training period required of new analysts.

CONCLUSION

The popularity of DB2 and ORACLE within the past few years has grown much more quickly than the actual development of production systems using either database management system. The advantages of relational database management systems -- mainly flexibility and heightened programmer productivity -- are apparent in the applications discussed above. At San Francisco State University, for example, the prototyping of a complex, seven-module online application using ORACLE has been a "win-win" situation. The disadvantages of 4GLs and relational DBMS packages, however, remain; poor response times for complex transaction processing and doubled space requirements (both in central memory and disk storage) are real limitations of current implementations. Future releases of both packages hint at microcode, or "turbo", enhancements. MIS shops choosing to implement SQL with relational DBMS packages prior to that time should be prepared to supplement hardware budgets and to rely on user fascination with the query capabilities for positive reinforcement.

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AUTOMATED DESIGN TOOLS: PARADISE OR PROMISES?

by

David Battleson
Greenville College
Greenville, Illinois

Marshall Drummond
Eastern Washington University
Spokane, Washington

John Moylan
Boston University
Boston, Massachusetts

Ruth Strausser
Georgia Institute of Technology
Atlanta, Georgia

ABSTRACT

The advantages of using automated design tools to assist with the design of complete systems, individual applications, or data structures have been touted in the literature and by vendors over the past few years yet few CAUSE member institutions report using these tools today. A 1986 survey of 400 CAUSE member institutions found that of 186 respondents only 3% use automated design tools for systems design, 13% use them for applications design, and 10% use them for data structure design. This report will review the current status of automated design tool technology, and feature reports on the use of automated design tools by three CAUSE member institutions.

I. A REVIEW OF AUTOMATED DESIGN TOOLS

PURPOSE AND SCOPE OF THE TOOLS

Automated design tools are often collectively referred to as CASE (Computer Aided Software Engineering) tools. CASE can be viewed as CAD/CAM for codesmiths, or in the broadest definition as the automation of anything a human does to software. Early (first generation) CASE was limited to graphics aids for the creation of data flow diagrams and structure charts, and various types of code generators. In much the same way that CAD/CAM has tied graphics to design metrics and engineering rules, CASE is integrating with other phases of the design life cycle, and automatically generating significant pieces of software and documentation. The degree to which the dream of automated programming, or the "programmer in a box" notion can be realized is subject to dispute. Brooks notes that any system which can generate code from specifications is forced to seek high levels of generalization. "It is hard to see how such techniques generalize to the wider world of the ordinary software system, where cases with such neat properties are the exception. It is even harder to imagine how this breakthrough in generalization could occur."[1]

CASE tools are gaining popularity, and the scope of these tools continues to increase. Maintenance concerns are being addressed by structured retrofit, data dictionary, and source code management products. Debugging tools are becoming more sophisticated, and the graphics tools which we categorize most closely with CASE are constantly growing in features and usefulness. "Now, CASE tools are starting to link those squares and ovals to the logic of structured design methodologies. Not only can designers speed up the rote job of drawing diagrams, but they also can use CASE tools to perform basic error checking. Some of the more sophisticated CASE wares can check details, right down through tree diagrams in which each function is decomposed into more detailed elements."[2] The reports in this paper demonstrate the wide scope of uses to which CASE tools are being put in three CAUSE member institutions.

LIMITATIONS OF THE TOOLS

There are some amazing stories of productivity increases due to the use of CASE tools. "..The application, which was originally expected to cost $268,000 was completed for a mere $30,000... We elected to use Application Factory for a 60-day trial and see what effect that would have on the overall project. We were surprized to find we could get the whole project done in the 60-day trial with just two people."[3]

While boasts of great productivity increases in specific instances are interesting, most managers would like to have a more defensible metric for measuring changes in productivity. While many shops have no consistent measure of software development productivity in place,a recent survey by Infosystems found that sixty nine percent of the respondents reported that they mearured programmer productivity, and that a surprising fourty six percent of those reporting were using function point measures.[4] It is interesting that several of the original producers of CASE tools are now vending productivity measurement software and methodologies.

The inability of CASE tools to help with program maintenance is a frequent complaint of new CASE users. "About two years ago we installed Pacbase, a comprehensive development system. Users were enthusiastic, and the project team was enthusiastic... We deinstalled it a year ago. Pacbase's maintenance works on applications developed with Pacbase, but for our existing systems we couldn't make it work."[5]

Another frequently limitation of CASE products is programmer acceptance. "It's difficult to get developers-the programmers and analysts-to use them. ..they don't see the tool as something that will increase their own marketability. Another reason is that all tools have some limitations. You get to a point where an application generator can't handle a particular problem. With the demand to provide users with perfect customization, you wind up having to program in COBOL anyway."[6] The level of integration of the components of a particular CASE tool with an installations existing DBMS and other software is also an item of frequent concern. Some software vendors, Software AG for example, are making significant strides in the integration of automated design tools with their existing family of development and operational products.

THE FUTURE OF AUTOMATED DESIGN TOOLS

Automated design tools are currently offering meaningful assistance to software development, and three such instances are reported in this paper. Especially helpful is the data dictionary integration which offers a single, controlled repository for forms, screens, procedures, data definitions, and data element usage mapping. The functionality of automated design tools and data dictionary features is certain to continue to increase in quality. Artificial intelligence and expert systems advances may result in improved CASE tools. Some leading software engineers doubt if artificial intelligence will be of much help to software development. "...Most of the work is problem-specific, and some abstraction or creativity is required to see how to transfer it."[7] Some experts believe that expert systems hold more hope for increasing programmer productivity and quality. "The most powerful contribution by expert systems will surely be to put at the service of the inexperienced programmer the experience and accumulated wisdom of the best programmers."[8]

The following reports show how three different automated design tools have been integrated into the design life cycle, and used to provide meaningful improvements in the software development environments at three CAUSE member institutions.

II. BOSTON UNIVERSITY - AN IMPLEMENTATION OF PREDICT

INTRODUCTION

Boston University is an independent coeducational, nonsectarian university located in Boston, Massachusetts. The university has a full-time equivalent enrollment of approximately 21,000 students and a faculty that numbers nearly 2,500. The University consists of sixteen schools and colleges and a medical campus.

COMPUTING ENVIRONMENT

University Information Systems provides the University's main adminstrative information processing support. An IBM 3090-180 mainframe running under MVS is used for mainframe administrative systems. Work is underway to expand an existing local area network, currently connecting most of the University's academic locations, to the main adminstrative processing site. This expansion of the network will assist in the distribution of the University's mainframe systems throughout the schools and colleges.

PRODUCT OVERVIEW

Predict is a mainframe data dictionary package, developed and marketed by Software AG. Predict is utilized with the database management system ADABAS and the fourth generation programming language Natural, both of which are also Software AG products. In the past, Predict has typically been used by organizations, such as Boston University, to record physical and logical representations (Userviews) of ADABAS files. Using Predict utilities, file definitions were generated to provide programmer access to ADABAS files. An additional use of Predict has been to document the data base environment by recording file and data element descriptions.

FUTURE DIRECTION

One of the future directions of Software AG is to more fully integrate their database products, while utilizing the Predict dictionary as a core system. Recent examples of this direction have included the introduction of a facility which, at the time program object code is generated, automatically records cross-reference information in the dictionary about the program, its processing components, (e.g. subroutines, maps) and the files and fields that they access. In addition, verification rules may now be recorded for data elements in the data dictionary and pulled into programs as a means of standardizing edits and reducing redundant coding.

INTEGRATION WITH THE DESIGN LIFE CYCLE

One of the Data Administration strategies utilized at Boston University is to integrate the data dictionary within all phases of the design life cycle. As a central repository for documenting the University's data, the data dictionary should provide systems developers and end users with the ability to obtain reliable information about the data and the functions available to access the data. By actively utilizing the data dictionary as a design tool throughout system development, the perception of system documentation as an obstacle to progress is avoided. Dictionary tools available through Predict are enhanced by inhouse tailoring and extension of the data dictionary. They are also supplemented with software packages available for use with Macintosh personal computers.

Entity modeling is employed as one of the techniques to analyze data requirements by graphically representing the organization's entities and the relationships between them. The fundamental rules about the the way in which data is used in the organization are also represented in these models. The use of this data modeling technique has proven to be very successful in promoting communication and in developing a common understanding of data. It also serves as a stable and lasting model of the organization, a basis for naming conventions and a first-cut representation of data base design.

Once entity models are finalized, the entities are reflected in the data dictionary as entity files (refered to as "standard" type files in Predict). These entity files become the central source for data element names, attributes and definitions. The standard attributes of fields within entity files are copied forward to form the actual fields within ADABAS files as well as "userviews" of these files. This is used to ensure ongoing consistancy of data element attributes and it also allows data elements to be defined only once, in the entity file, regardless of the number of physical files in which they may eventually appear.

Data element names are made up of an abbreviated form of the entity name, the domain class (e.g. identifier, flag, date, code, etc.) and one or more words to provide meaning. We have developed functions to support dictionary maintenance which check for use of standard abbreviations when new data elements are named. The abbreviation table used to support this function is also used to translate the abbreviated data element names into full words within data dictionary reports.

End users are actively involved in the development of entity models and in defining data elements, since they have the most complete business knowledge of the data. A modified version of the standard Predict functions has been assembled to support end user involvement throughout the system design life cycle. Included within the tailored data dictionary functions are options allowing documentation for files, fields, systems, functions and maps (screen layouts) to be recorded. To support standardization, guidelines regarding the type of questions to be addressed by the documentation are provided as part of online dictionary functions. An interface is also included to a "screen painting" facility which allows system developers and/or end users to jointly develop draft images of online screens during the system design process. The finalized screen layout is reflected as part of the lasting documentation for online functions.

DISTRIBUTED INQUIRY AND MAINTENANCE

The availability of accurate, informative and complete system documentation supports an organization-wide objective of distributing the functionality of existing mainframe systems to University departments. The increased awareness of existing systems helps to reduce costly duplication of both data and processing of data.

The distribution of data dictionary maintenance is an issue which has been addressed through developing multiple update profiles for the data dictionary. System developers are given a data dictionary maintenance profile which allows them to represent data requirements for new files or modifications to existing files. This is accomplished through the creation of Predict "concept" files. The use of "concept" files allows system developers to analyze several design options while utilizing data dictionary tools to verify conformance with Data Administration standards. The creation of the physical ADABAS file and generation of logical views of this file are performed by Data Resource Management following a file design review process. This review process weighs factors such as flexibility, data redundancy, semantic clarity, efficiency, security, programmer ease of use, and ongoing data integrity to determine an optimum design.

An additional data dictionary maintenance profile is provided to end users to promote their active involvement in the system design life cycle. This profile allows them to view existing file descriptions and to update definitions of data elements for which they are the data trustee. Both Data Administration and the data trustee must approve data element definitions before they are finalized within entity files. Various report options are also made available through this dictionary application to facilitate documentation review.

NEW OPPORTUNITIES

Data dictionary profiles are currently being enhanced to allow more extensive documentation to be recorded regarding systems, applications, online functions, programs and maps, in addition to files and fields. Relationships between online functions, the system(s) which they are part of, and relationships to sub-functions and programs invoked within functions may all be reflected in the data dictionary. The use of keyword/subject searching has also been built into this enhanced version to facilitate inquiries. In addition to supporting documentation of implemented University application systems, the capability to centrally document and analyze business models is regarded as a potential future use of the Predict data dictionary. As opposed to the entity model, which documents data relationships, the business model reflects important business activities of the organization including hierarchical relationships between business functions.

As analysis progresses forward to file design, it is envisioned that information gathered in business modeling and translated into function specifications may be utilized to automate logical access mapping. This cross-referencing of functions and their data access requirements, combined with statistics regarding anticipated frequency of function utilization, may be used as the basis for determining file design and assignment of file access keys.

SUPPORT SERVICES

In order to move in the direction of automating data analysis and database design, we have attempted to more formally integrate design tools with our systems development methodology. A series of system life cycle checkpoints involving Data Resource Management, have been developed as guidelines for Project Leaders and Systems Analysts. A small internal committee, chaired by Data Administration, is currently in the process of formalizing these checkpoints and developing documention to support them. For each checkpoint, documentation will include:

- brief description of the checkpoint
- purpose
- examples
- involvement (who is responsible, participates and reviews)
- procedure, including the level of detail
- tips and techniques

In addition, it is recognized that, at the commencement of every project, an evaluation of internal training needs should be conducted. Documentation from this Checkpoint Review Committee will be passed on to our internal training area as a basis for developing a training program.

PRODUCT EVALUATION

Without enhancement, the Predict data dictionary fails to meet many of our design related objectives. The cost of tailoring this package must be constantly weighed against the ability to provide improved support of both application staff and end user requirements. However, the close ties between Predict, ADABAS and the programming language Natural, which is utilized for nearly all new program development, provides a compelling opportunity to pull together the components of our development environment. We anticipate that our direct form of technical data dictionary support may be minimized in the future. To achieve this goal, we look forward to more powerful and flexible releases of the Predict data dictionary as well as the availability of improved mainframe and personal computer based design tools which ideally, will interface with the data dictionary.

III. GEORGIA INSTITUTE OF TECHNOLOGY - AN IMPLEMENTATION OF WORKSHOP 204

INTRODUCTION

The Georgia Institute of Technology is a single-campus, state assisted university located in Atlanta, Georgia. Georgia Tech was founded in 1885 and is a unit of the University System of Georgia. The institution has an enrollment of over 11,000 students in architecture, engineering, management and the sciences. The undergraduate enrollment is approximately 8,500 and the graduate student enrollment is approximately 2,500. Georgia Tech ranks first among public universities in engineering research and development expenditures.

COMPUTING ENVIRONMENT

Data processing software support for administrative users is provided through the Department of Information Systems and Applications (ISA). Computer operations support is supplied by the Office of Computing Services (OCS). The campus is served by GTNET, an optical fiber network providing access to all computers. There are a number of mainframes available, including:

1. Cyber 180-810 - 16 megabytes of memory and 1.55 gigabytes of disk storage - Plato, CAE/CAD.
2. Cyber 180-830 - 16 megabytes of memory and 3.12 gigabytes of disk storage - CAE/CAD.
3. Cyber 180-855 - 16 megabytes of memory and 15.88 gigabytes of disk storage - Administration.
4. Cyber 180-855 - 64 megabytes of memory - Academic/Student Usage - NOS operating system.
5. Cyber 180-990 - 32 megabytes of memory and 24.6 gigabytes of disk storage - Academic and Research - NOS-VE operating system.
6. IBM 4381-R14 - 32 megabytes of memory and 45 gigabytes of disk storage - Administrative and General Academic - MVS operating system.
7. IBM 4341 - 16 megabytes of memory and 7.5 gigabytes of disk storage - CAD/CAM.

Most administrative student related computing is handled by Cyber 855 using the NOS operating system and DMS-170 Database Management System.

Many administrative accounting functions are handled by a Cyber 855. MSA General Ledger, Accounts Payable and Budgetary Control packages and Information Associates Alumni Development System are resident on the IBM 4381. The Model 204 Database Management System, under which a vehicle registration and citation processing system has been developed, as well as several small applications supplementing the MSA packages, runs on the 4381. Printing is handled by Xerox 9700 and 8700 laser printers, a high speed Cyber impact printer and distributed line printers.

WORKSHOP/204, MODEL 204 DATABASE MANAGEMENT SYSTEM

Descriptions of the product:

WORKSHOP/204 is a collection of integrated tools designed to facilitate the development of full-scale applications in a MODEL 204 environment. MODEL 204 is the current, commercial version, of what

Computer Corporation of America called a "software system" when it was developed as an information storage and retrieval system in 1967. The name is derived from the term data model since MODEL 101 was one of the first implementations of an inverted data model. Initial development was funded by Bell Labs, which sought an advanced data model for rapid access to large online databases. The MODEL 100 series which included MODEL 103, an interactive system under DOS, and MODEL 104, an interactive system under OS were not actively marketed, although the first sale was to the University of Illinois in 1969. In 1971, the product was significantly enhanced, renamed MODEL 204, and the first sale was made to the Department of Defense.

MODEL 204 was developed specifically for an integrated, online database environment. An online, interactive System Command Language permits database structures to be created and modified dynamically. User Language is a complete database application development tool which truly can be used by both data processing and nondata processing personnel. The system's Resource Management Facilities provide the ability to dynamically monitor and adjust MODEL 204's performance. The database structure ensures data independence and maximum flexibility. The System Command Language, User Language and Resource Management Facility are all native to the MODEL 204 nucleus. In addition, the MODEL 204 nucleus has direct interfaces to IBM's teleprocessing access methods: VTAM, TCAM and BTAM, which means less work in building an interactive application.

Responding to the vicissitudes of commercial competition, CCA acquired and developed a number of products to assist in system development. DICTIONARY/204, PAINTER/204, ACCESS/204 and PC/204 have been available since 1984. Several of these products and others have been brought together in WORKSHOP/204 - a product which, as advertised, integrates a collection of tools designed to facilitate the development of applications in a MODEL 204 environment. It has been available since early 1986. WORKSHOP/204 offers facilities for:

- Defining an application subsystem
- Defining and prototyping databases and views
- Generating screens and procedures to manipulate data in a view
- "Painting" screens
- Editing User Language code
- Documenting applications
- Creating test data
- Testing

Each WORKSHOP facility automatically documents its results in the dictionary. Programmers may invoke DICTIONARY/204's Documentation facility through WORKSHOP to augment the system controlled dictionary data with their own descriptions. Subsystem Management: The subsystem management facility allows the developer to define a collection of User Language procedures to form a production application requiring minimal end user knowledge of MODEL 204. The developer enters information about the subsystem: files, procedures, error handling and security. The facility provides the driver and maintains its own error handling and security. Subsystems improve performance by saving and reloading compiled procedures defined to the facility as "precompilable".

File Management: Database definition is accomplished through the file management facility. The user enters information about file characteristics, field attributes, record layouts, and field groups. Based on information provided, the file is sized. Changes may be executed immediately or in a delayed batch mode. The dictionary entries and the MODEL 204 files they describe are synchronized.

View Definition: Views are collections of logically related fields defined by the user from file definitions. View definitions specify the records and fields to be retrieved, how the data is to be displayed, display names or column headers, convenient width to be used and may include validation criteria. Different views may be relationally joined based on common field values to form a composite view. Views are used by the Screen and Action Generator, and the Query/Update facility. Views are also used by the query/report generator (ACCESS/204), and PC204, which permits retrieval, updating and data transfer between mainframe and personal computer, without having to write programs.
Query/Update: This facility is a prototyping tool for developing MODEL 204 applications. Its use enables one to create, modify, query, and update views of data without actual file creation or programming, using a system-provided file, or to perform system prototyping using an existing MODEL 204 database. It also provides a means of populating a file with test data.

Screen and Action Generator: Using a previously defined view, this facility generates a screen and "action" procedures which use the screen to manipulate data. The action supports querying, updating, displaying, and deleting of data. The generated procedures can be modified using Procedure Editor. The screens can be modified using Screen Painter. Screens and procedures generated may be used as building blocks of applications.

Screen Painter: This facility is used to create and modify screens. The user "paints" the screen, then specifies screen item attributes. Screen Painter generates the User Language code which defines the screens described in this way.

Procedure Editor: The facility enables the user to define procedures and to edit User Language code with the full-screen editor. It supports specifying characteristics of the editing sessions, such as mixed case or upper case and maintenance of aspects of the procedure definition, such as the aliases and the procedure security class.

Documentation: The user may enter descriptive data to dictionary entries of any entity type. It is useful for expanding information stored with system-generated data and for adding data that is not system-controlled.

Single-Step Test: Using this facility, it is possible to test applications subsystems by stepping through User Language procedures with several options available between each step. The name of the next procedure to be executed may be viewed and changed, global variables may be viewed and changed, any procedure may be edited, a temporary request may be run, runtime statistics for each procedure may be displayed.

As noted earlier, WORKSHOP/204, in addition to automatic updating of the dictionary, provides access to the facilities of DICTIONARY/204, the online interface to MODEL 204's dictionary.

SPECIFIC USES OF THE PRODUCT

As background for a discussion of Georgia Tech's use of MODEL 204 and of our experience in using WORKSHOP/204, it should be noted that our acquisition of a database management system for use on the IBM 4381 was a part of a long range plan for comprehensive institutional data management which included moving all administrative systems from the CYBERs to the IBM 4381. Progress in implementing that plan has been much slower than we orginally hoped it would be. We have been now for some time in a process of intense re-evaluation of existing systems, particularly in the area of the institution's business administration. The policy of the institution remains, however, to purchase package software if adequate products are available. In-house systems development is limited to applications for which no satisfactory commercial product exists. That custom work which is done is primarily on small ancillary sytems.

MODEL 204 was installed at Georgia Tech in November of 1985. The initial system installed included PAINTER, DICTIONARY, ACCESS/204 and Subsystem, the application subsystem management facility. Our use of PAINTER, DICTIONARY and Subsystem has been extensive. WORKSHOP, which incorporates these and the other facilities described was not released until early 1986 and was installed at Tech in November 1986.

The applications developed under MODEL 204 include a campus vehicle registration and parking system, inquiry to combined purchase order, invoice and check data, an accounts payable document tracking system, an interim alumni development system and a general ledger/property control interface.

PRODUCT INTEGRATION IN THE DESIGN LIFE CYCLE

The vehicle registration portion of a proposed campus parking system was chosen as a pilot project to be implemented on the system. Although design work for such a system had been done earlier, a considerable amount of time was spent working toward a data model in third normal form.

It's only fair to the vendor, CCA, and to the product, to emphasize that my comments in relation to our use of products now incorporated in WORKSHOP/204 describe our experience with earlier versions of them. While the names are the same, access to them is improved and the specific problems we encountered have been resolved.

Files, records, fields and procedures were identified through DICTIONARY - an incredibly laborious task at the time. To enter, or even accept the default attributes for a field, for example, it was necessary to progress through no less than six screens - and woe betide the fumble-fingered person who made a mistake - it was impossible to return to a previous screen in the sequence. It was necessary to progress to the end, then re-enter the function (change a entry) to correct the error. The motivation for using DICTIONARY, however, was strong - not only was there a desire to use the facets of this product we had, but DICTIONARY provided the "Database Interface" function - which sized the file and produced the file parameters and field definition statements to be used in creating a new MODEL 204 file. This facility, of course, made use of the file, record and field definition entered in the DICTIONARY. So, to the inexperienced database manager, the drudgery of dictionary entry seemed a small price to pay for some built-in "professional" assistance in file creation.

In addition, a long-term goal of our organization, rich in the accumulated product of more than 25 years of student record and administrative data processing programming, was to define the "institutional data" in an online dictionary. This project offered an opportunity to display the potential benefits in making use of such a facility.

The ability to add user-defined entities to the dictionary is an extremely useful feature. We made use of it to add further documentation, such as source of data, use, coding, format, initial content, editing, retention period and authority, which included manager, owner, custodian and user identification. PAINTER was also extensively used in development of the systems described. It's far easier to "paint" a screen, modify and re-modify it until it meets approval, than it is to code statements, test, then code again. PAINTER provides a default set of screen attributes or allows attributes to be defined by the designer. Since we use color monitors, this was a feature pleasing to some who used the product. We experienced a high level of frustration at times due to inherent product problems (inability to correctly deal with a many-item screen, occasional gratuitous duplicate entries for screen items in the metadata file, for example) and due to lack of knowledge about relation of the product to some "system" files (the wrath of a programmer who has spent an hour or more designing a screen and laboriously defining attributes only to lose it all because a temporary file is full is a sight to behold).

EVALUATION OF THE PRODUCT FOR PURPOSES USED

Despite problems with both products during the course of developing the systems described, they surely contributed to productivity. Each of the systems described was developed by a different person - each person working in a MODEL 204 environment for the first time (one in an IBM environment for the first time). The interval of time from assignment to release for production use in every case included the "What's M204, what's User Language" period, system design, file design, screen design and coding. The fact that the simplest systems were up and running in 3 weeks, the more complex in four to eight weeks, speaks well for the useability of the products - and for the capabilities of our staff.

WORKSHOP/204 which incorporates products with which we are familiar, does improve ease of use of DICTIONARY and PAINTER. The other facilities provided, particularly the prototyping capability offered and the screen and action generator, should prove extremely useful.

File and field definition, which is a function of DICTIONARY/204, is a much smoother and more efficient process in the version incorporated in WORKSHOP. Field attributes, for example, may be defined on one screen, rather than the previous laborious process of moving through six screens for each individual field.

PAINTER is more reliable. As with all the WORKSHOP products, it's now possible to remain in one of the facilities, moving forward and back, until satisfied with the results before completing the function. Previously, once begun, the apparent assumption was that the user would progress in an orderly fashion from start to finish of any function - little recognition of the all too frequent failings of most us which cause us to benefit from the opportunity to regroup and fix the oversight.

FUTURE PLANS FOR THE USE OF AUTOMATED DESIGN TOOLS

We plan to use WORKSHOP/204 facilities in the design and implementation of future administrative data processing support systems. We will make fuller use of prototyping because our limited experience proves its an invaluable tool in working with users to define the real problem. Use of the WORKSHOP facilities for data definition, screen design and procedure coding has the overarching benefit of forcing a level, and certainly an immediacy, of documentation not previously achieved.

Our experience after a recent series of in-house training sessions also indicates that WORKSHOP moves an inexperienced staff member much more quickly into productive participation in the development cycle. In the world of database design, for example, or at least in our world, there are myriad details to be considered in file design and field description - other than the familiar "what type, what size" situation. Being prompted to consider those details produces a better end-result more quickly.

SUMMARY

Does WORKSHOP/204 provide "paradise or promises"? In Milton's words "The mind is its own place, and in itself - Can make a heaven of Hell, a hell of Heaven". In the minds of those who need to launch inexperienced staff members into rapid productivity in an unfamiliar system - and who wish to maintain a degree of documentation, extracted from those staff members only against their will, it comes close to providing a paradise. To those who have, by whatever means, struggled through a learning phase and achieved a degree of competence in dealing with the database and development under it, WORKSHOP/204 is one of those "user friendly" systems we're all familiar with - when you know what you want to do and how to do it, having to pass through voluminous numbers of optional question/answer items tries the patience of the most saintly. However, even the experienced person, committed to the principle of at least minimal documentation, will welcome the automatic dictionary update which WORKSHOP/204 provides. SCREENGEN, the applications screen and code generator, while perhaps most useful to newer users, also offers relief from basic design and coding to veterans.

The product is a good one. It is useful - it delivers much of what it promises - particularly if use is instituted at the outset of moving to a MODEL 204 database management system environment.

IV. GREENVILLE COLLEGE - AN IMPLEMENTATION OF EXCELERATOR

INTRODUCTION

Greenville College has had a computer since 1978 and has developed all of the administrative software systems using College personnel. During school year 1985-86, a decision was made to upgrade the computer hardware and to investigate different software systems. Several different software vendor's systems were evaluated and compared by the different functional offices of the College. A decision was made to upgrade only the hardware using the same vendor that was already being used by the College. A Data General MV8000-II was ordered to be installed during the summer of 1986. This decision was based on several factors:

1) Several of the functional offices were very happy with the internally developed software and saw no improvement of their information needs by changing to some other vendor's software.

2) Data General's academic software program included software which would significately improve the administrative and academic uses of the computer on the campus.

3) This would be the easiest change from one computer to another. All the data bases were dumped to tape and rebuilt

on the new computer and the program sources were dumped to tape, loaded on the new computer and recompiled.

Part of the Data General software package included some components of automated system design tools. These include Data Dictionary, a Screen Generator, a Program Generator and a Source Management System. Each of these components are seperate pieces of software and we found them very weak in the areas of documentation, ease of use, user friendliness and linkage to each other.

After several months of use and evaluation we determined that these components of automated systems design tools were not sufficient to do automated system design and implementation. We then decided to purchase an IBM PC/AT and also purchase the software package called Excelerator. The IBM PC/AT was purchased to implement a network with the other IBM PC computers which were already on campus, mostly in a computer science laboratory. Excelerator is one of several CASE tools which runs on the IBM PC/AT and Excelerator was choosen because of previous experience in using the product. We knew of Excelerator's capabilities and that our internal documentation would greatly improved.

USES OF THE PRODUCT

The Excelerator product was first used in the re-development of an information system for the Admissions Office of the College. This system was completely designed by using Excelerator. When the design phase of the Admissions Systems was nearing completion, we decided to enter the complete data dictionary of all of the administrative systems for the campus into Excelerator's repository. Additionally, in several major maintenance projects we have used Excelerator to develop better documentation from which the users have a better understanding as to how the changes will effect other processes and how the changes will be implemented.

We are currently using Excelerator in all parts of our system development life cycle including new systems development and systems maintenance. During the summer of 1987 we changed the method of charging students. Previously we would wait until the last add/drop cut-off day and then charge all students their charges and apply some of the Financial Aid. We changed to a system of charging at the time of the enrollment line completion.

Several functional areas of the College were involved but very few knew how the data intregrated to create a student bill. With the assistance of Excelerator we were able to create documentation which clearly defined and explained how these processes were performed.

EXTENDED USES OF THE PRODUCT

Excelerator is linked with WordPerfect and with Harvard Total Project Manager. This gives the user of Excelerator the ability to move to the other software products without returning to the operating system. Data files can be transported from Excelerator to WordPerfect. Data Flow Diagrams, prototyping reports and screens, data stores, entity list, structure diagram are a few of the pieces of documentation which Excelerator can generate. The pieces of documentation from Excelerator and documentation from both Harvard Total Project Manager and WordPerfect help us make better presentations to users and give both users and the designers a better understanding of the information requirements of the different systems being developed.

Excelerator is also being used in course work assignments in a systems design class which is a part of the computer science major offered at Greenville College. Members of this course must design a system of some kind and several members of the course select projects which will become a part of the administrative system of the college. Some of systems which have been developed using Excelerator include:

1) College Work Study Accounting System
2) Purchase Order Entry
3) Encumberence Reporting

FUTURE USES OF THE PRODUCT

We have decided to use Excelerator as a repository for our corporate data dictionary. We have loaded information about all of the financial/accounting functional information systems elements and all of the student information systems elements into the product. There are still other areas of out information system which need to be loaded into Excelerator. We plan to do all future system development using the Excelerator product and feel that this would give us a better way to manage our corporate data dictionary. We also envision the possibility that we may change the vendor of our main computer or even add mulitple computer vendors. We feel that we can more easily move our data from our current software to other software, another hardware vendor or even add multiple computer vendors and still be able to manage our data dictionary without converting our data dictionary to some other software/hardware format.We are uploading some information from Excelerator to out Data General MV8000-II to assist in the program development process.

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